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LRAPP VERTICAL ARRAY - PHASE IV

C. H. Jones

Westinghouse Electric Corporation

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Earlier reports (Phase II and III) describe a vertical array of hydrophones that were built by Westinghouse Electric Corporation for measuring noise in the ocean at frequencies from 10 Hz to 300 Hz. This report describes modifications and tests of this equipment for a deployment that was made near Bermuda on November 12, 1974. The array is 3600 meters long and contains five hydrophones.

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1. INTRODUCTION

ACODAC deployment No. 33 was made near Bermuda on Cruise IV, Leg 4 of the R/V Chain on November 12, 1974 in 4030 meters of water. Westinghouse Electric Corporation (Ⓦ) prepared a set of cable sections, hydrophones and circuits for this deployment. Ambient noise measurements were recorded at frequencies from 10 Hz to 600 Hz. Five WX-VERAY-3 hydrophones were mounted on a vertical cable as shown in Fig. 1. These hydrophones have a self noise level below the lower Wenz sea state noise curve,[1] and have a low sensitivity to acceleration, -58 dBV/mg or better. These small, rugged, winchable hydrophones shown in Fig. 2 have been described in detail in earlier reports.[1,2,3,4]

In preparation for this deployment the sensitivity of the hydrophones to 4.5 Hz strumming frequencies was reduced by at least 15 dB. Hydrophones were calibrated as a function of static pressure so that a proper sensitivity value is available for any depth at which the unit is used.

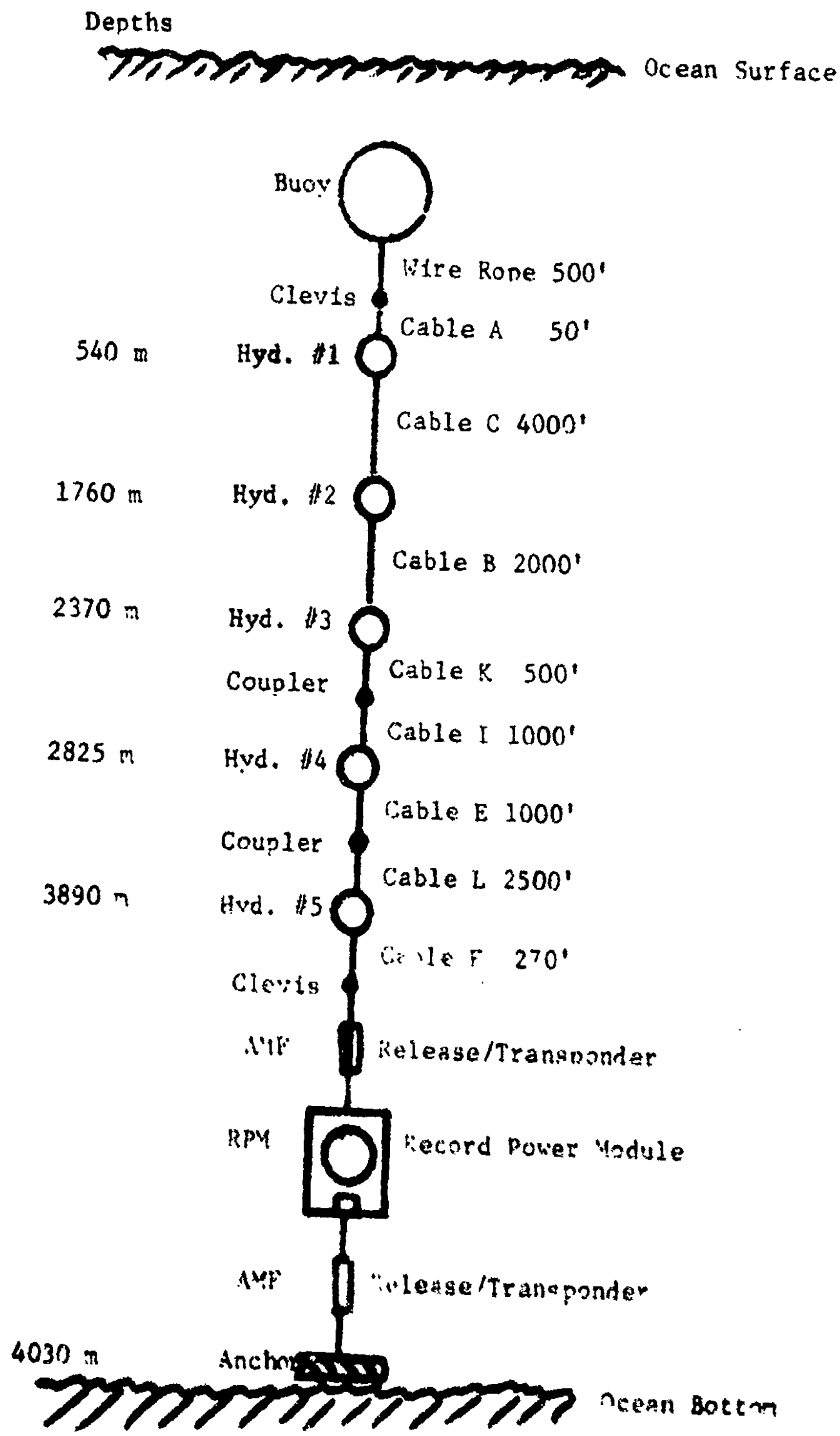

Fig. 1 - Vertical Array used in Deployment #33

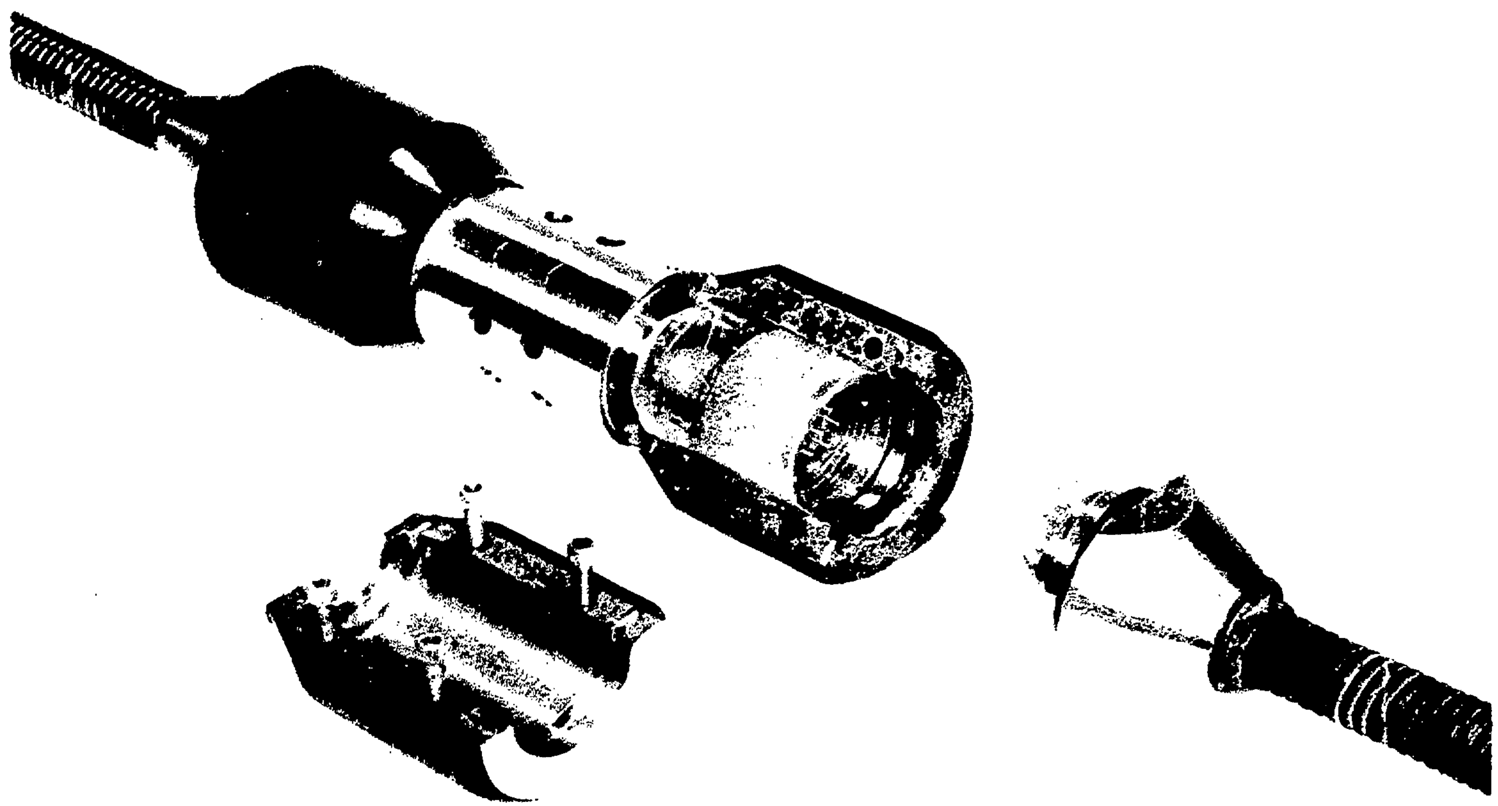

Fig. 2 - Westinghouse WX-VERAY Low Noise, High Sensitivity Hydrophone

2. HYDROPHONES

The pairs of split couplers that provide mechanical coupling to the cable at each end of the hydrophones were machined to a larger inside diameter to eliminate pinching the molded polyurethane connectors. Some of the amplifiers were rebuilt using a metal encapsulation for each semiconductor element. The design of these units is shown in Fig. 3. The leads were brought out through holes in a micarta disk and the unit was sealed with epoxy. An extra lead was brought out to an eighth pin on the male connector so that the preamp can be tested electrically without any acoustic signal.

The hydrophones used in this deployment were calibrated by the Naval Research Laboratory[5] to obtain sensitivity as a function of frequency and static pressure. The frequency response of each unit at 2°C and 55 MPa pressure is given in Figs. 4 through 8. The 100 Hz sensitivity at 2°C is plotted as a function of static pressure in Figs. 9 through 13. Table 1 lists the 100 Hz sensitivities of the five hydrophones used at a temperature of 2°C.

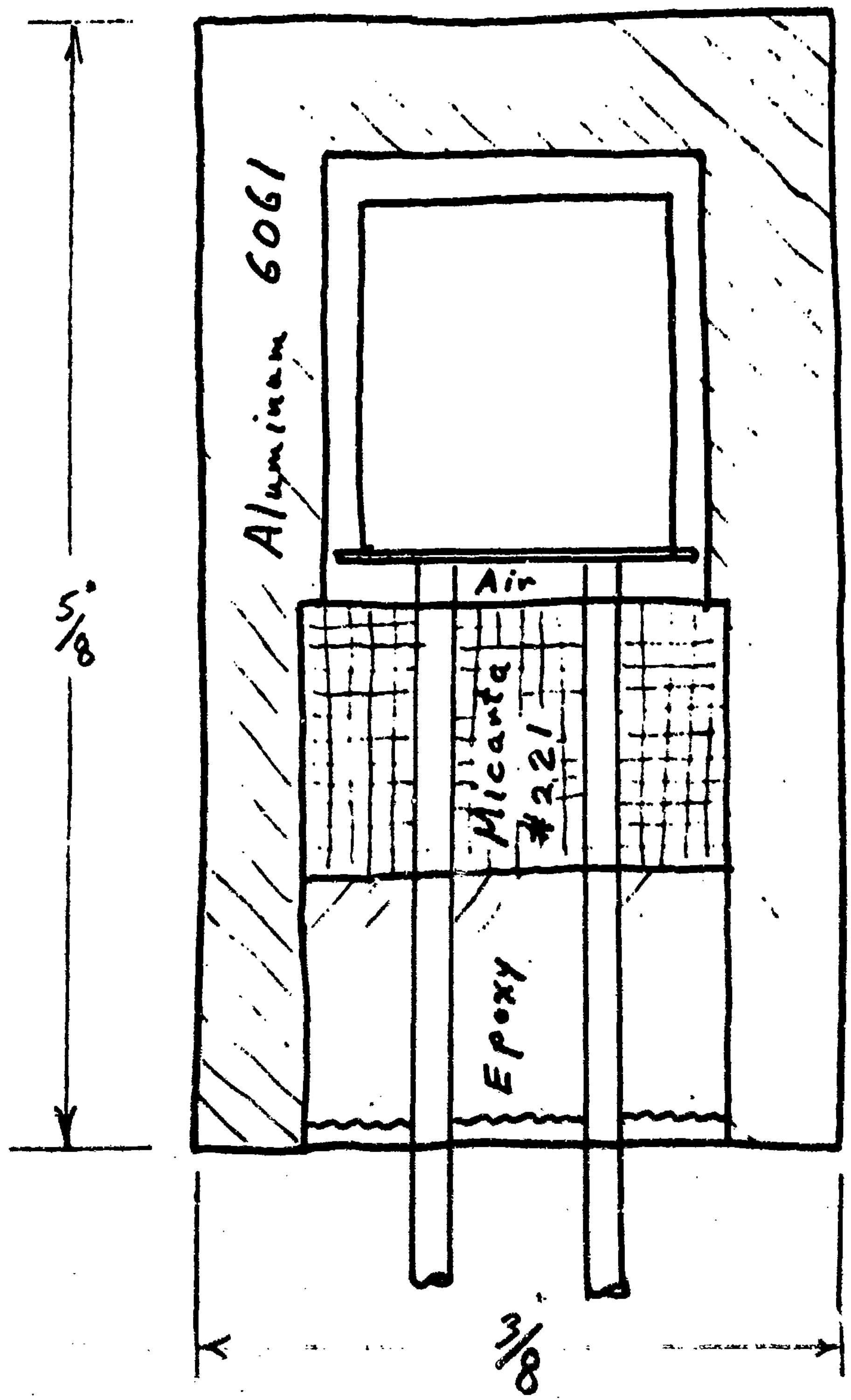

Fig. 3 - Semiconductor Encapsulation Assembly

TABLE 1 - Hydrophone Sensitivities

Hydrophone		Deployment			Sensitivity 100 Hz and 2°C	
		Depth		Pressure	at 55.1 MPa	at deployed depth
Position	Serial	ft	m	MPa	dB re 1 V/ Pa	dB re 1V/ Pa
#1	A17	1770	540	5.4	-150.3	-148.0
#2	A19	5780	1760	17.6	-150.1	-148.7
#3	A5C	7780	2370	23.7	-150.0	-148.8
#4	A21	9280	2825	28.2	-151.0	-149.7
#5	A23	12780	3890	38.9	-149.9	-149.3

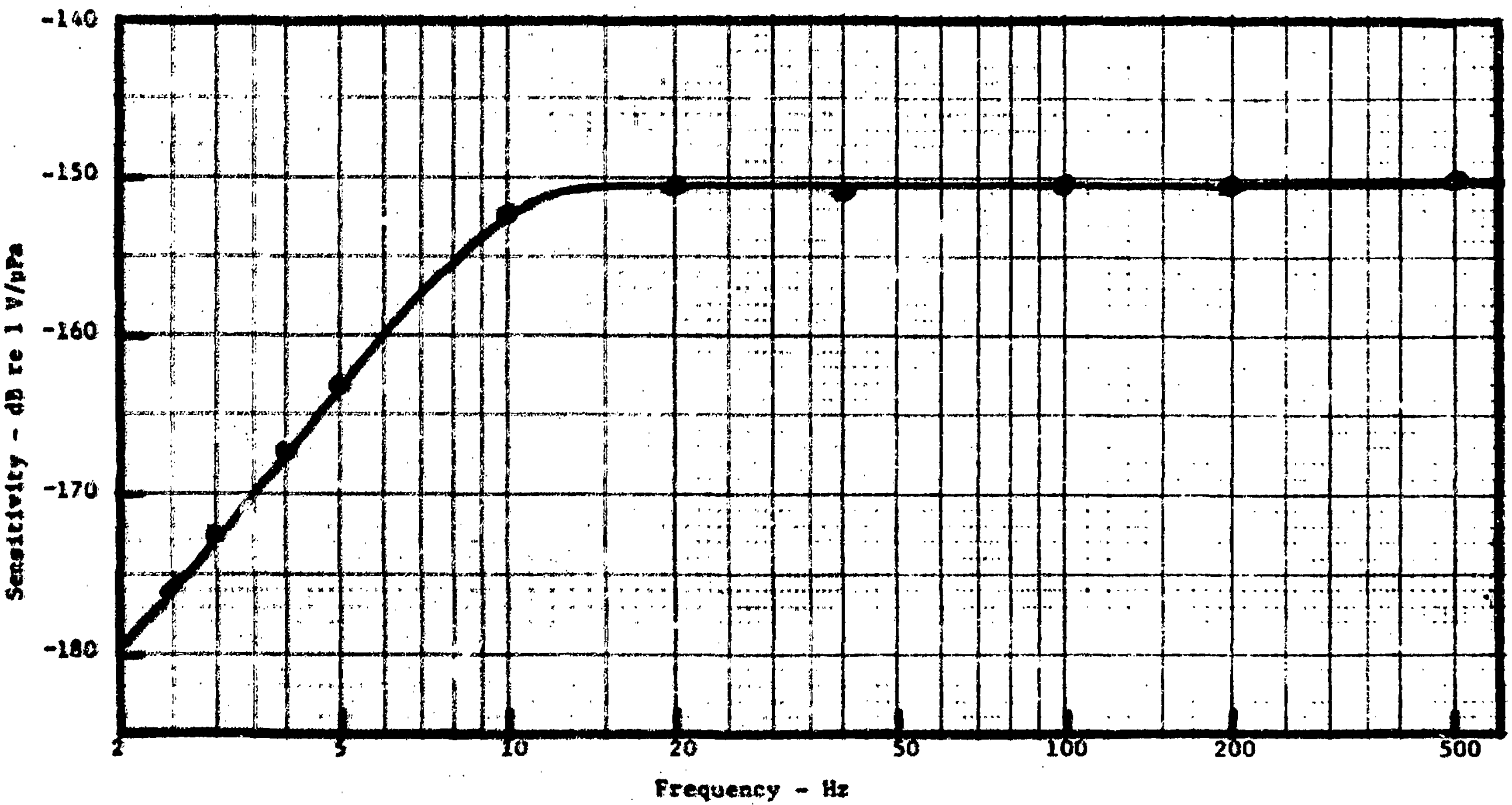

Fig. 4 - Sensitivity of Unit A17 at 55 MPa Pressure

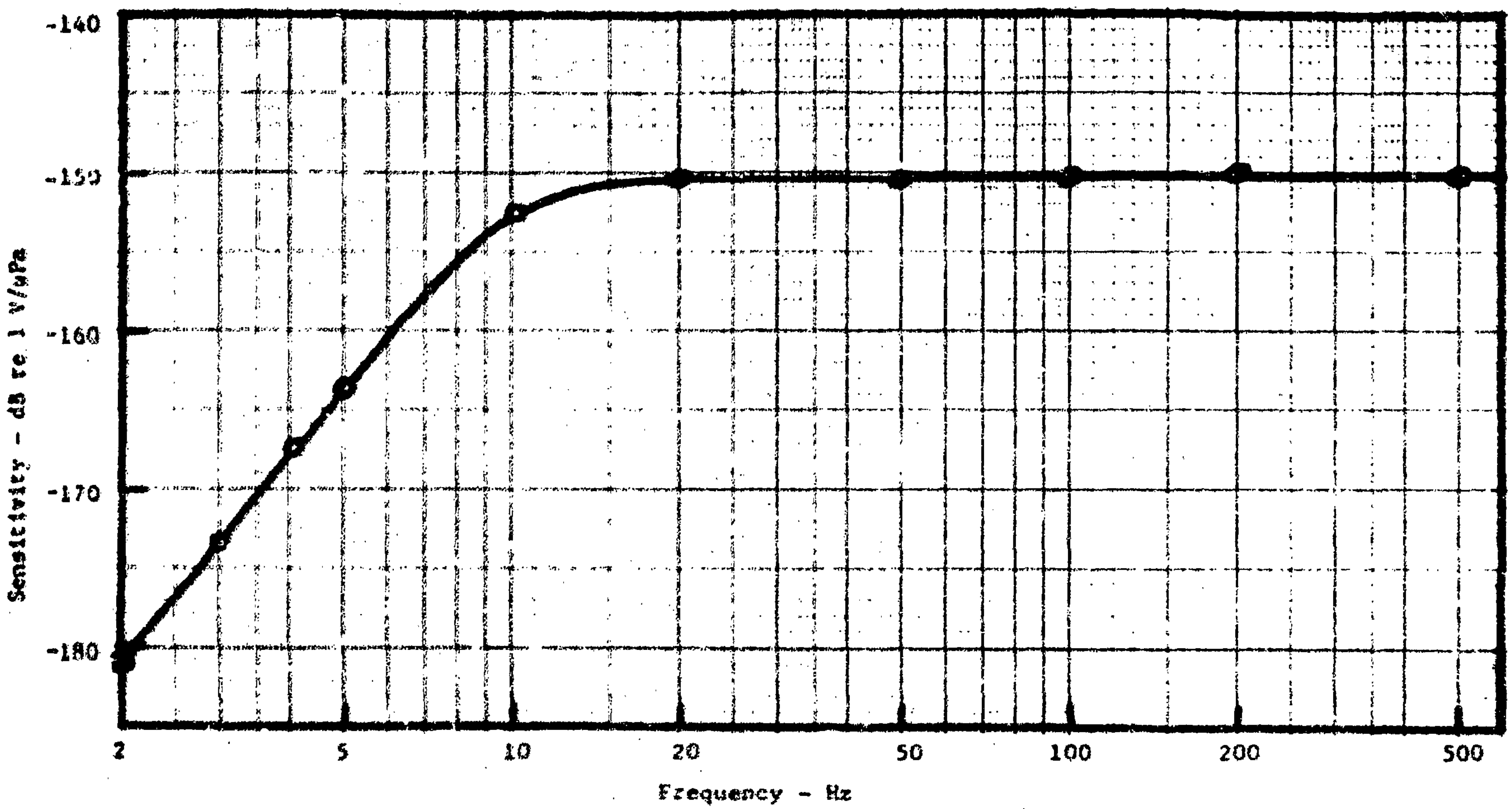

Fig. 5 - Sensitivity of Unit A19 at 55 MPa Pressure

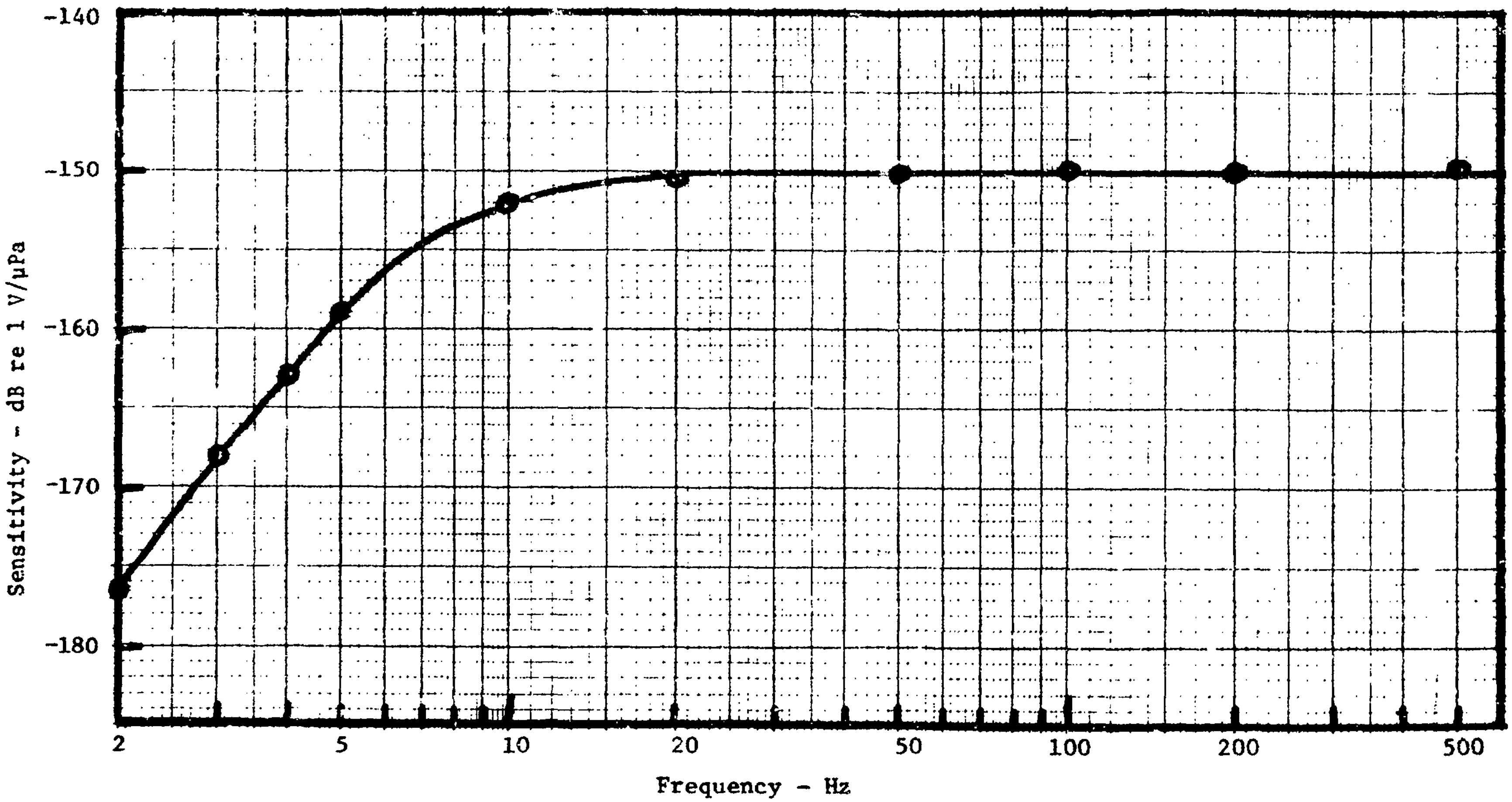

Fig. 6 - Sensitivity of Unit A5C at 55 MPa Pressure

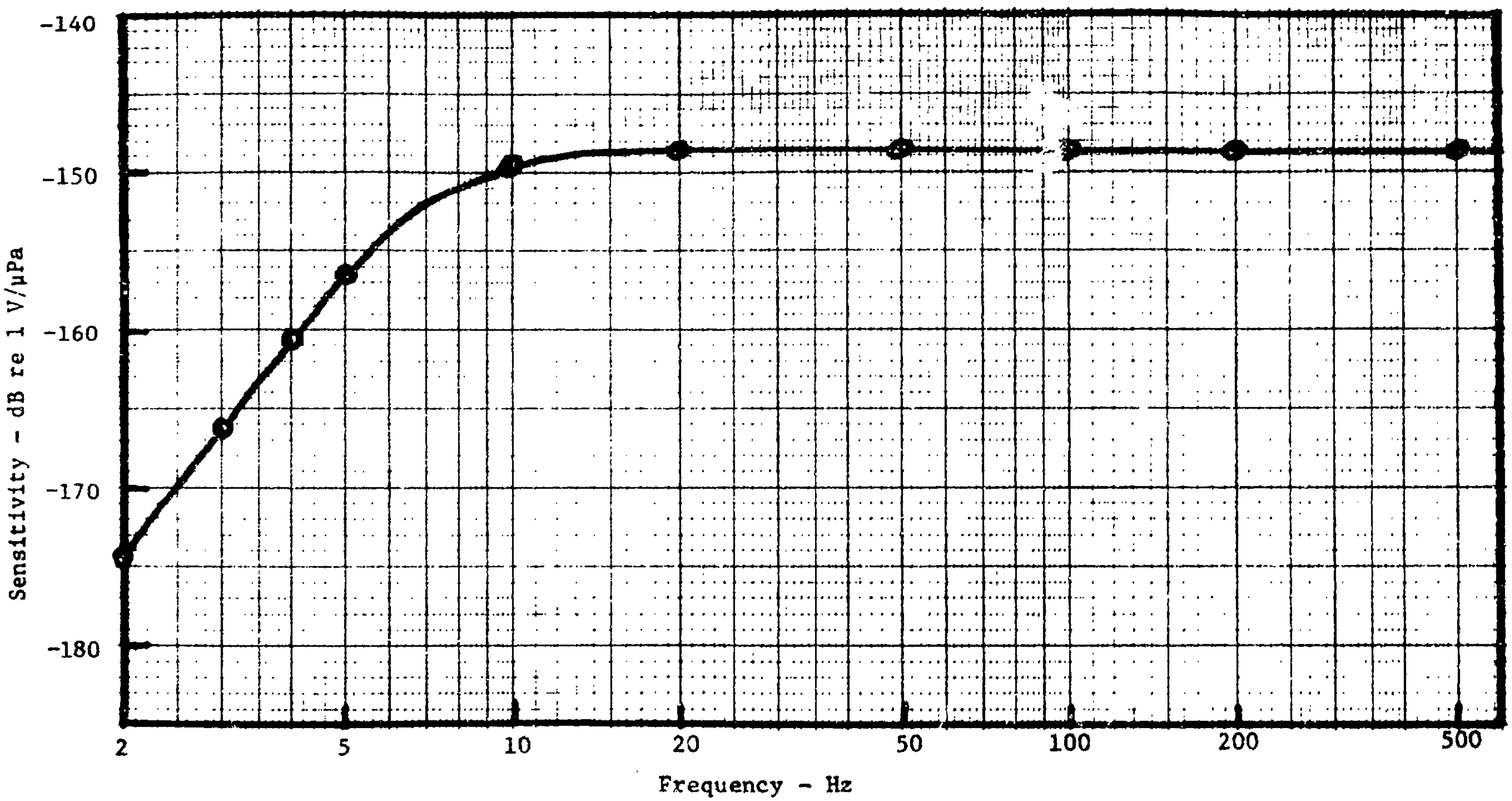

Fig. 7 - Sensitivity of Unit A21 at 55 MPa Pressure

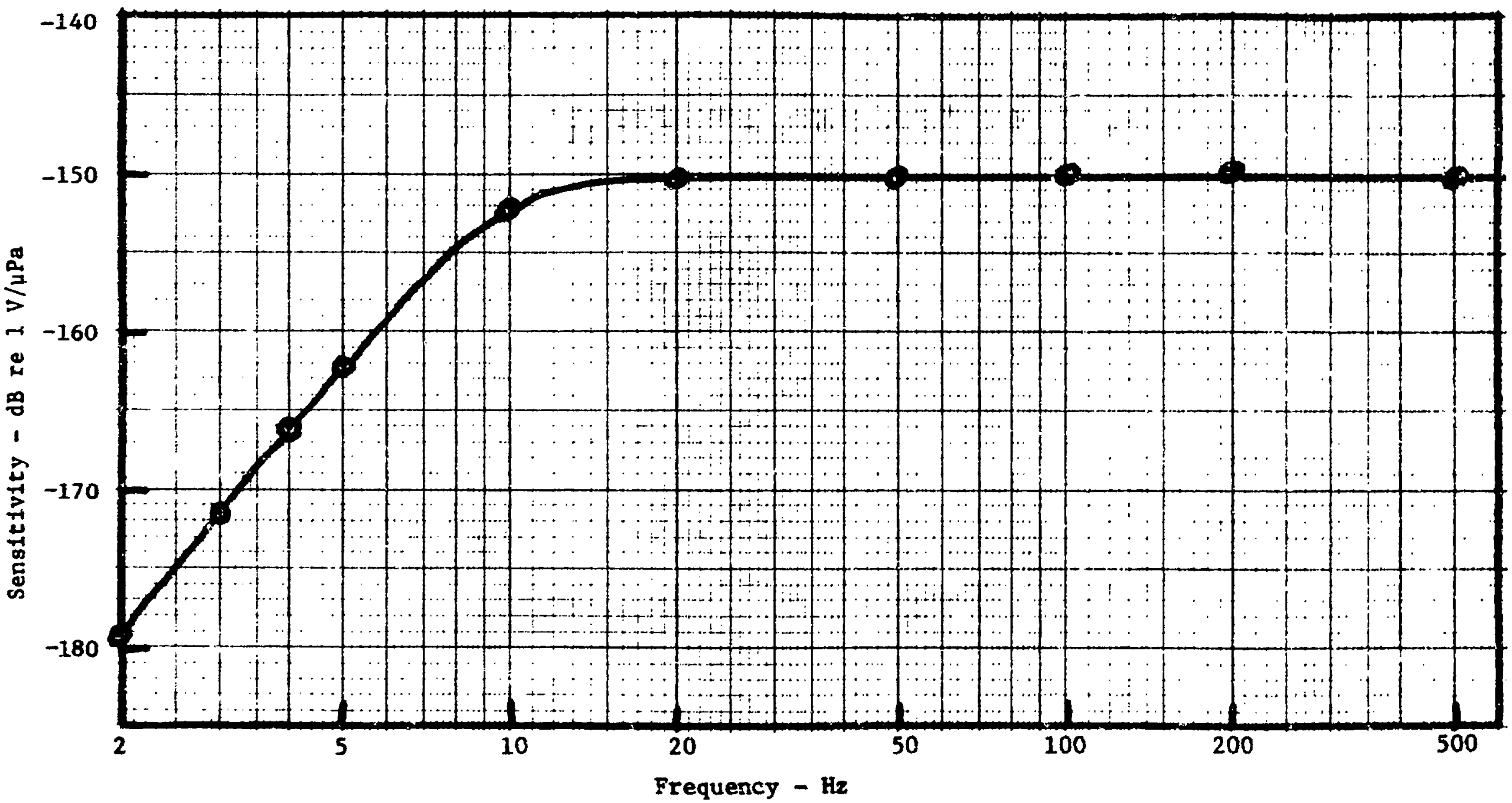

Fig. 8 - Sensitivity of Unit A23 at 55 MPa Pressure

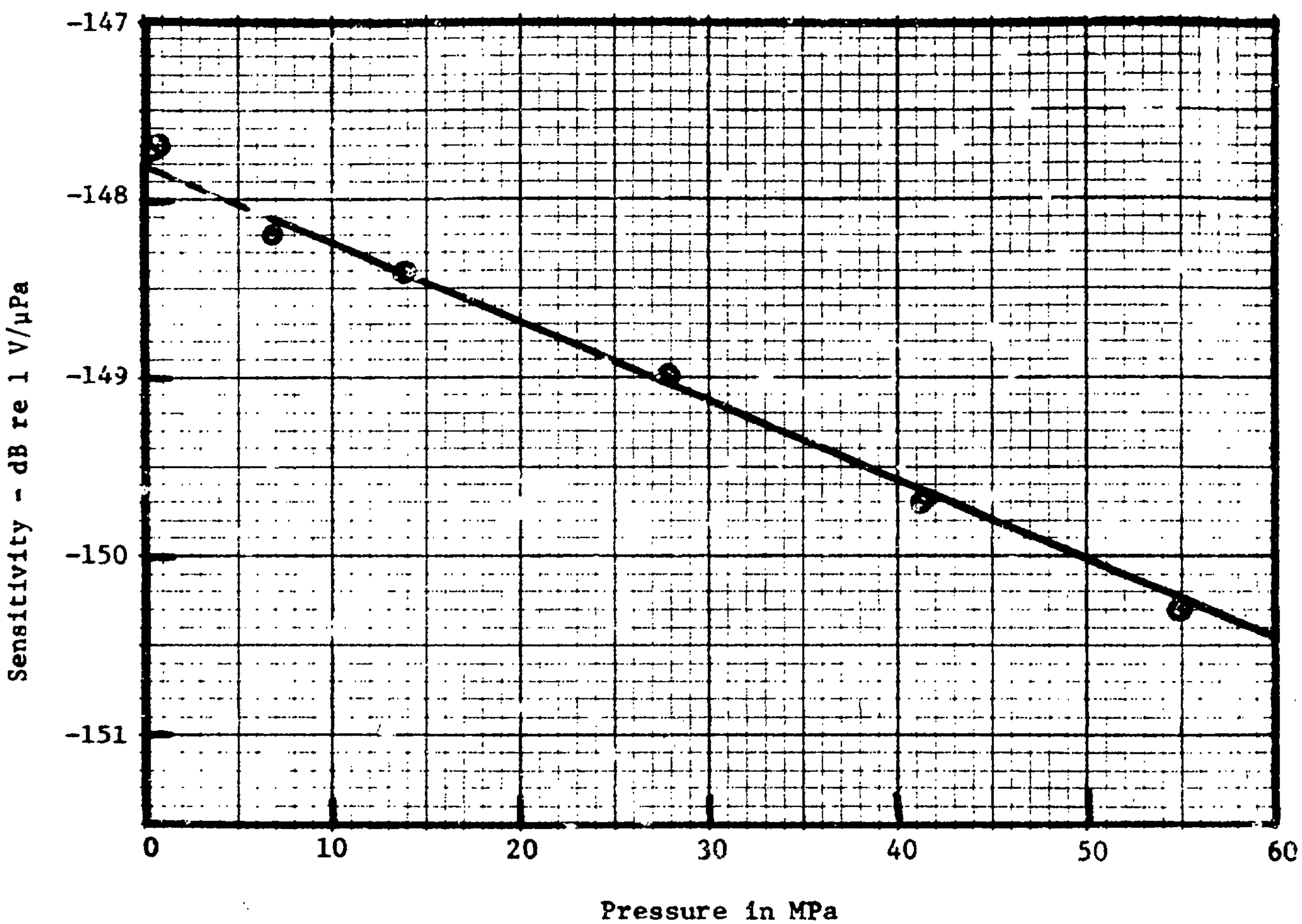

Fig. 9 – Sensitivity vs Static Pressure of Unit A17

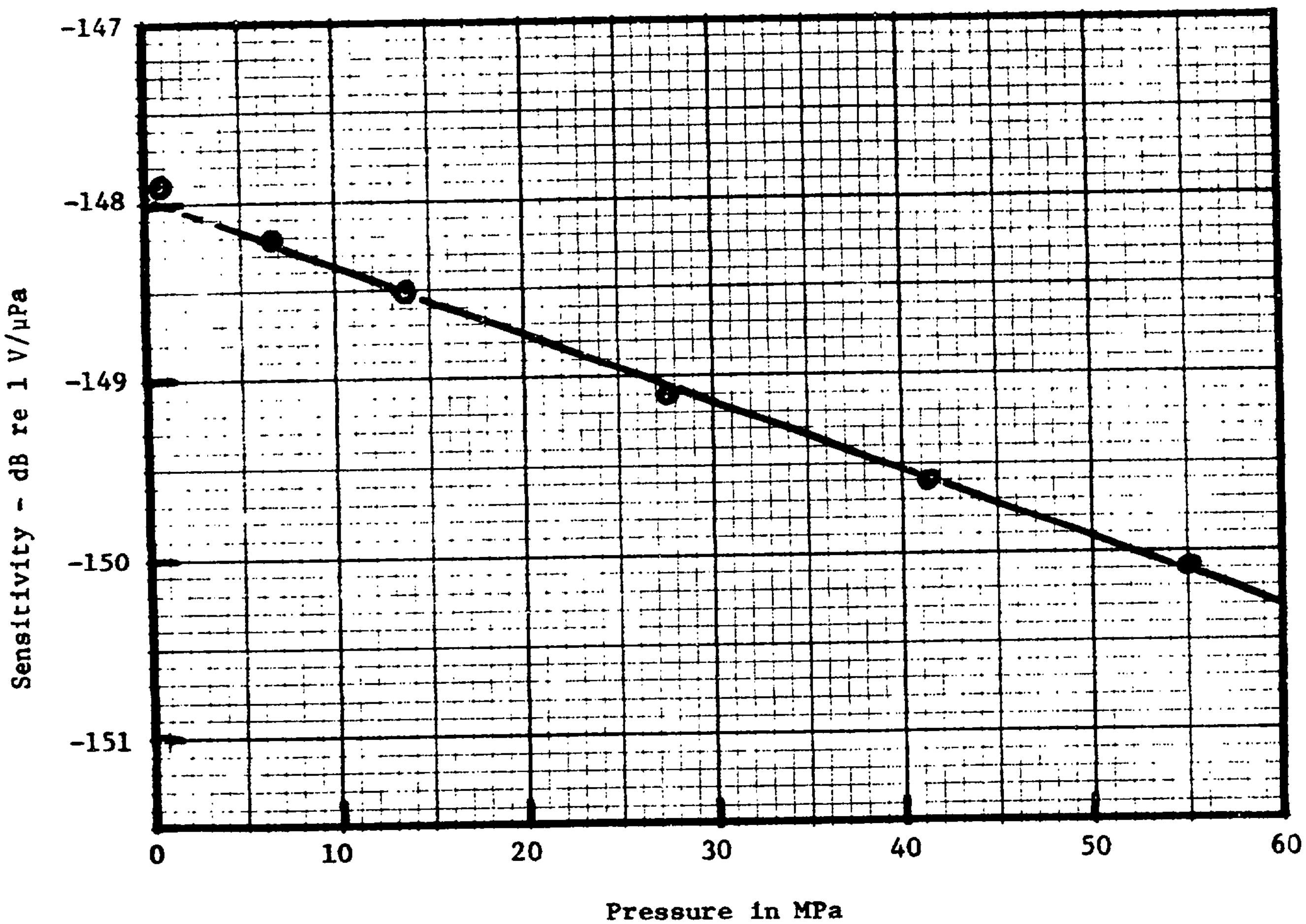

Fig. 10 - Sensitivity vs Static Pressure of Unit A19

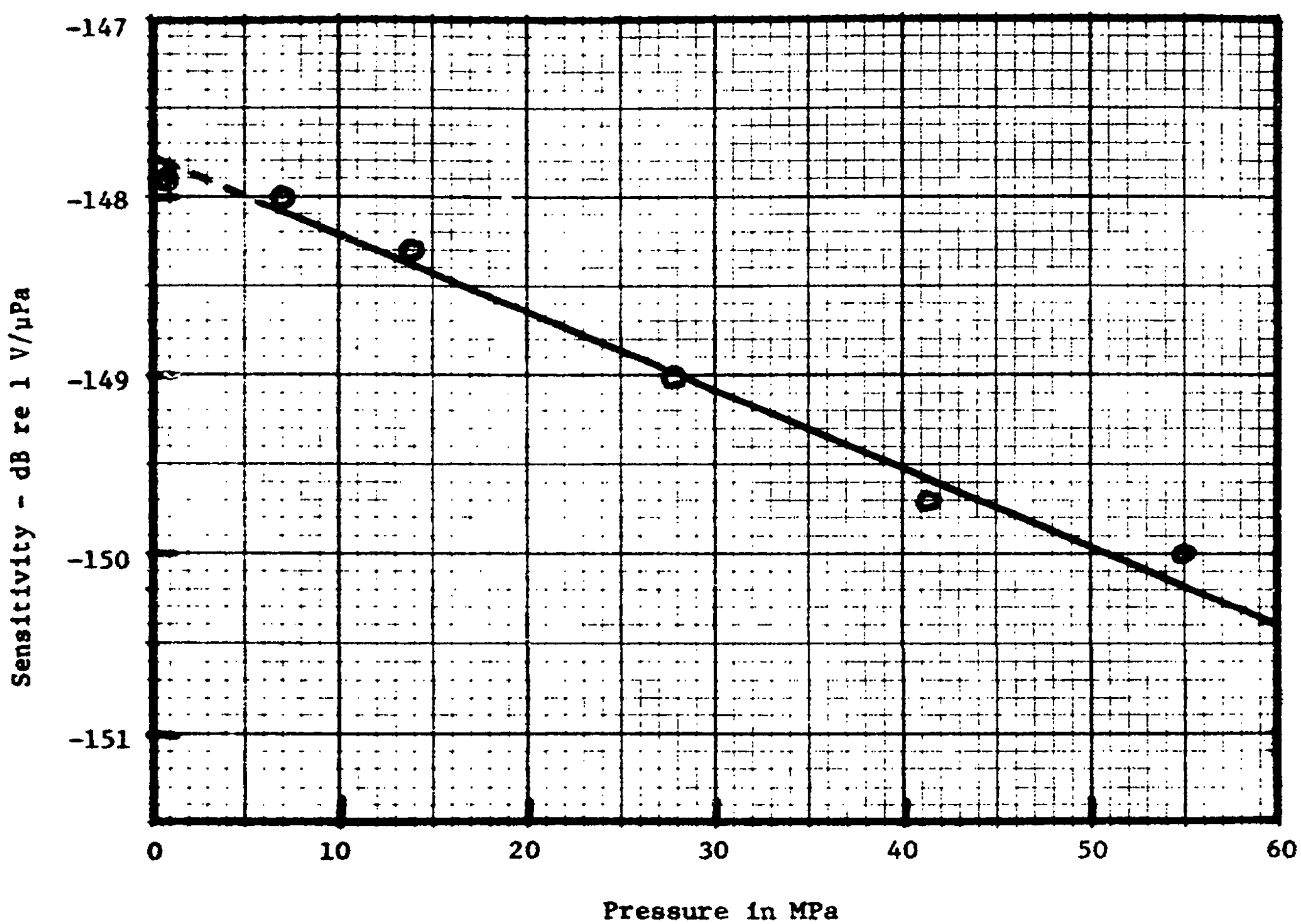

Fig. 11 – Sensitivity vs Static Pressure of Unit A5C

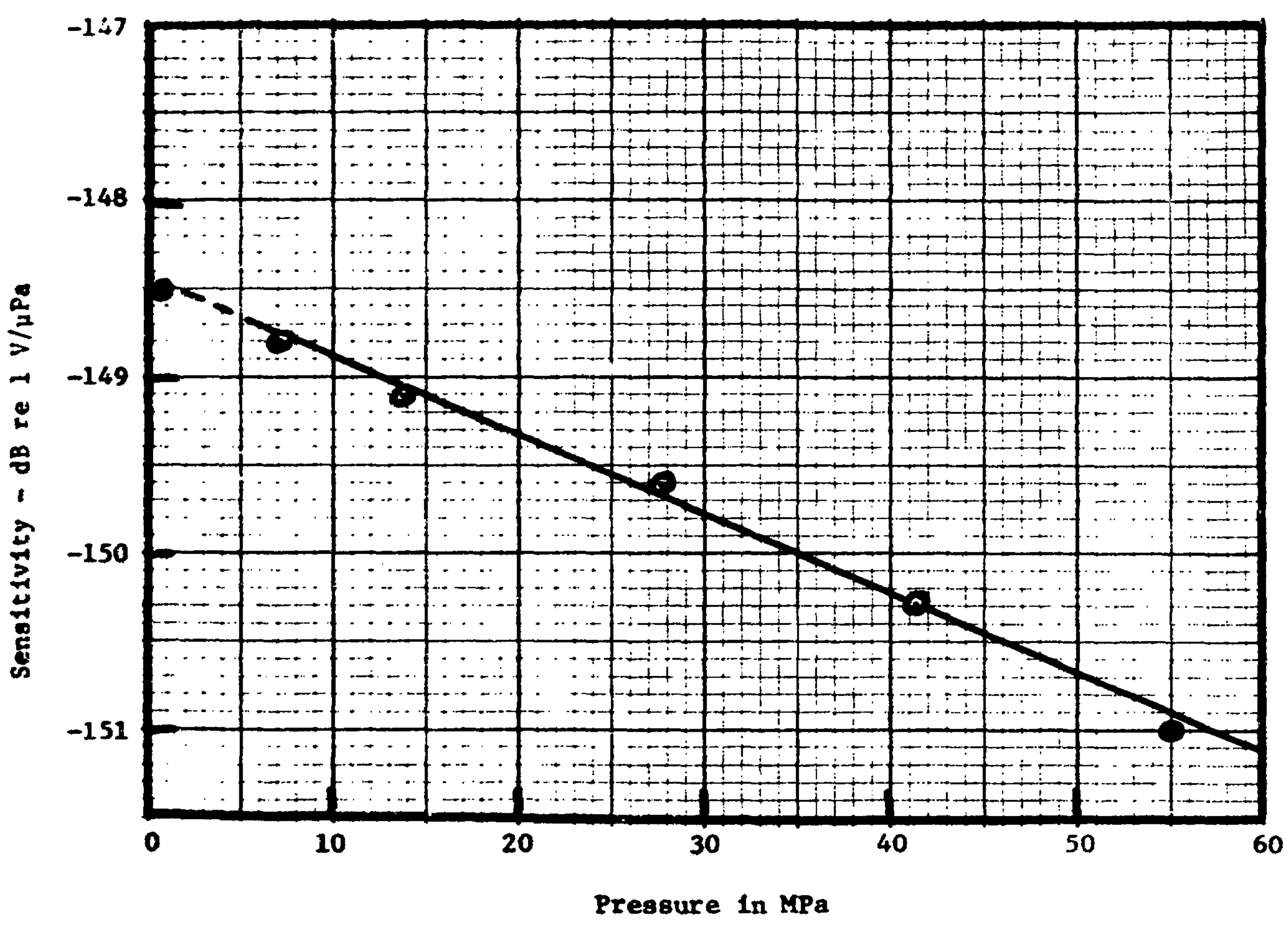

Fig. 12 - Sensitivity vs Static Pressure of Unit A21

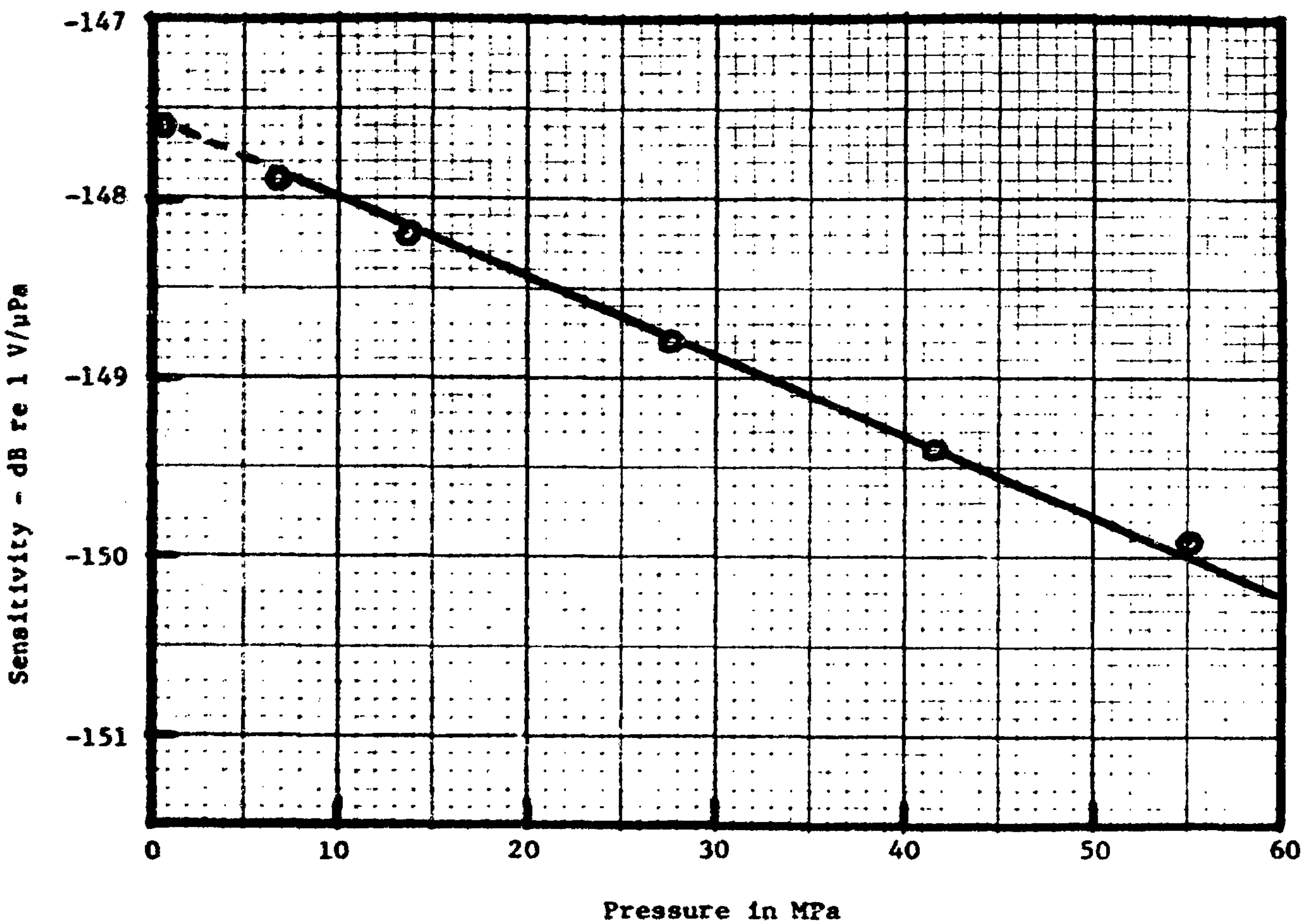

Fig. 13 - Sensitivity vs Static Pressure of Unit A23

3. CIRCUITS

A preamplifier circuit is potted in polyurethane at one end of each hydrophone and is protected by the split coupler that also protects the electrical connector. A power converter unit and five termination amplifiers for the five hydrophones are enclosed in an aluminum chassis which is mounted inside the sphere containing the magnetic tape recorder.

3.1 Preamplifiers

Some new preamplifier units were built which used semiconductors. A 100 ohm resistor, R8, was inserted in series with the hydrophone line as shown in the new schematic, Fig. 14. An eighth pin was added to the male end of the hydrophone and a lead was brought out from the common line between R8 and the hydrophone cylinder so that the gain of the amplifier can be checked electrically. An a.c. voltage of 100 Hz applied across R8 is amplified by a factor of 100 by the combined preamplifier and termination amplifier units.

The original hydrophones with their associated amplifiers had a flat frequency response from 10 Hz to 1000 Hz as shown in Fig. 15. The peaked response at about 4 Hz was considered undesirable because cable strumming might saturate the amplifiers. Consequently, the preamp units were modified by a proper choice of R11 and in some units by adding C2. As a result all the new amplifiers built had a gain at 4.5 Hz that was at least 10 dB less than the response at 50 Hz. See Figs. 4 through 8. The method of choosing R11 is given in Note 2 of Fig. 14.

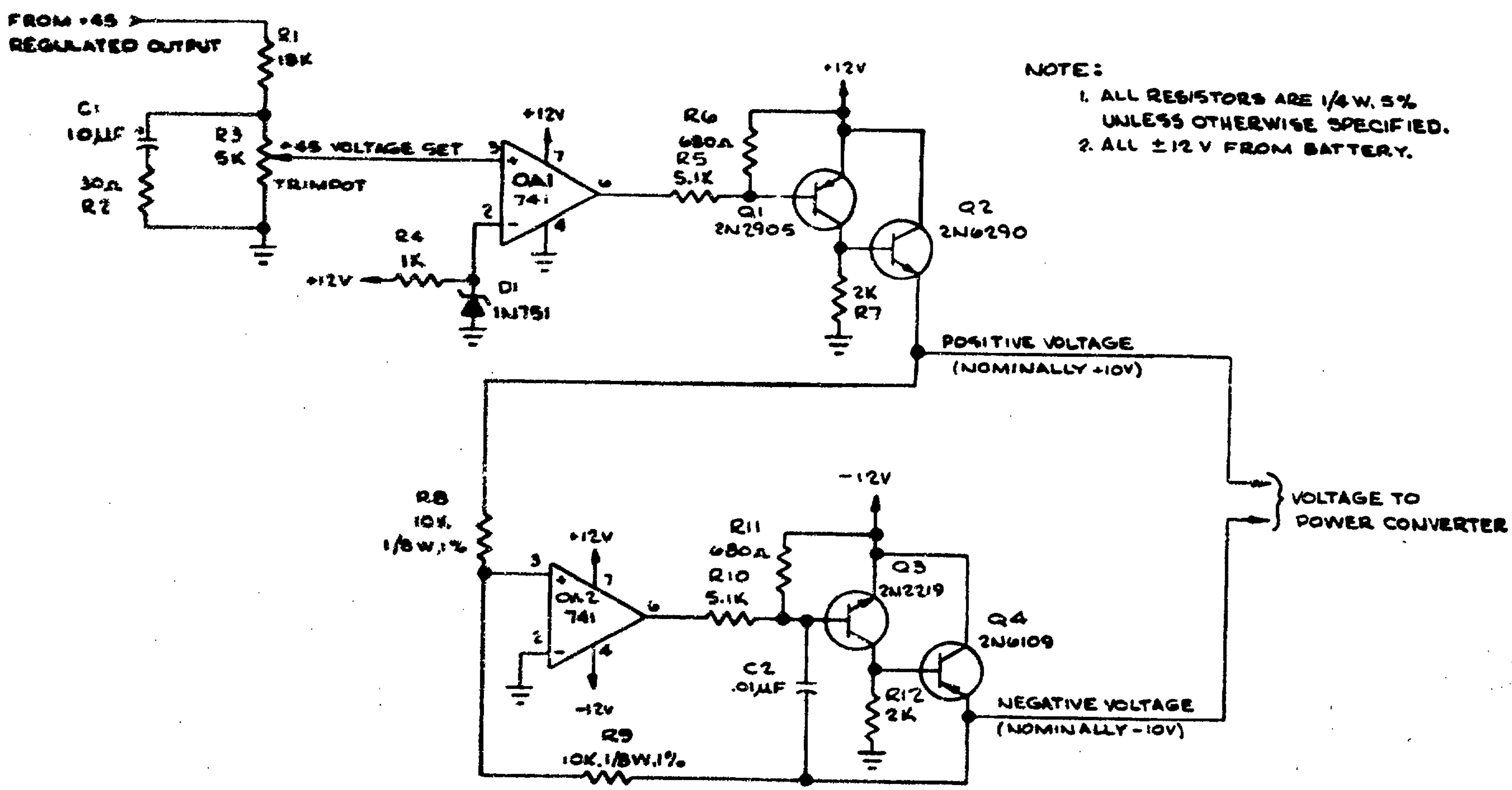

Fig. 14 - VERAY Preamplifier Circuit

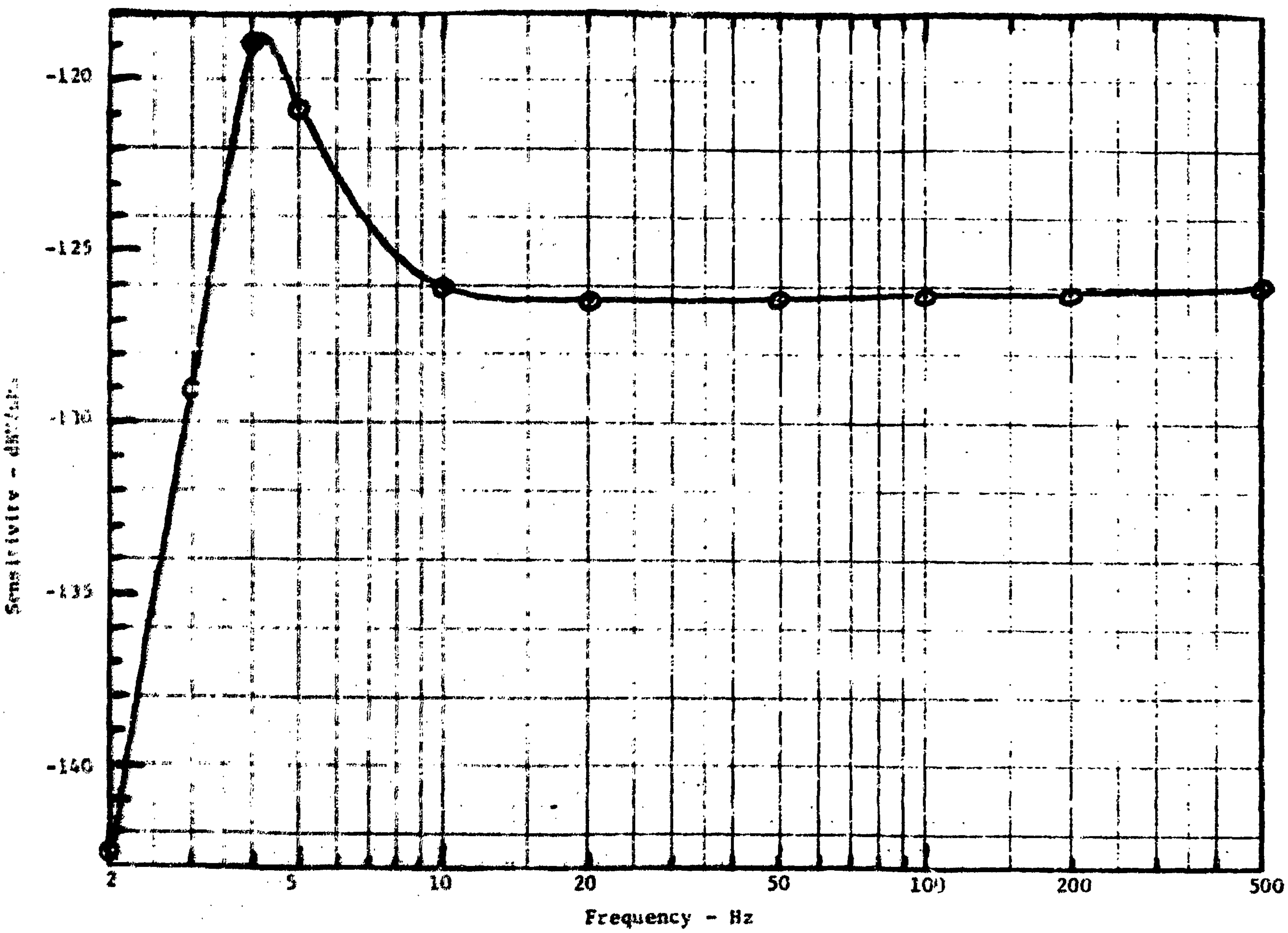

Fig. 15 - Frequency Response of Original WX-VERAY-1 Hydrophones

3.2 Termination Amplifiers

The termination amplifiers used in this deployment, Fig. 16, were similar to the units used in earlier deployments except that the values of R1 and R2 were changed to those values given in Fig. 17, so that with the cable lengths given in Fig. 18, the d.c. voltage on all preamps were equal and the a.c. termination load seen by all preamps were also equal.

The array wiring diagram is given in Fig. 18. The symbols H1 through H5 represent the hydrophones and associated preamps. The termination amplifiers are designated as A1 through A5. Input and output leads from the termination amplifiers were coaxial line to minimize crosstalk and noise.

Capacitor C3 was added to roll-off the termination amplifier frequency response in order to attenuate the 20 kHz ripple voltage and converter noise injected into the amplifier from the +45 V line through L1 and R2. The negative side of capacitor C1 was returned to point A rather than ground so that the C1 charging current would not flow through current sampling resistor R8 in the power converter. This eliminates the possibility of converter shutdown immediately after start-up due to sensing of this current.

3.3 Power Converter

A block diagram of the modified power converter unit is given in Fig. 19. This unit derives its power from the $\pm$12 V battery voltage which can vary from 14.5 V when the batteries are fully charged down to 10.5 V when discharged. A regulated output voltage of +45 V is provided for the termination amplifiers which each draw 14 ma of current. The regulator output voltage was reduced from 10.5 to 9.6 volts. The regulator unit was completely redesigned in order to eliminate the oscillatory behavior of the previous design. The new circuit is given in Fig. 20.

The converter overcurrent shutdown circuit was redesigned as shown in Fig. 21 to eliminate the possibility of shutdown immediately after start-up.

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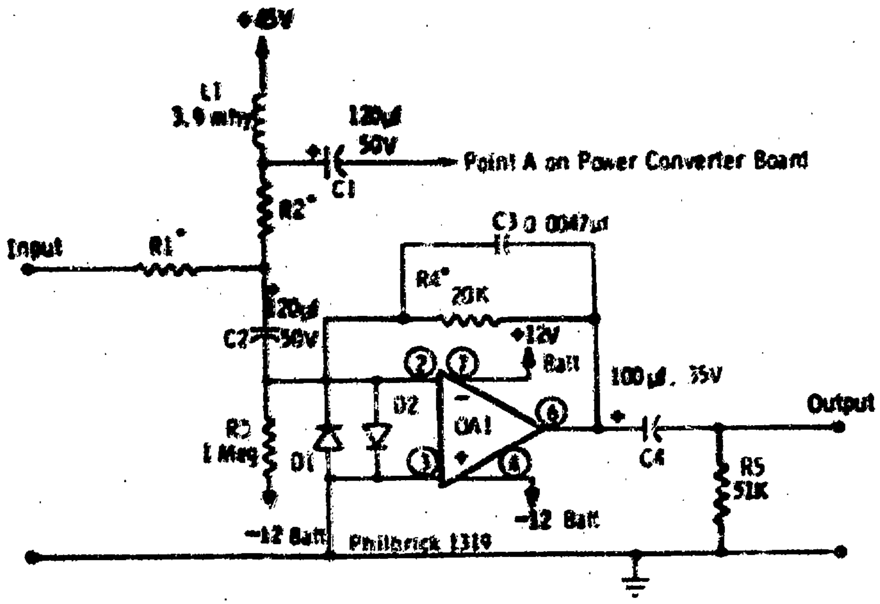


A termination amplifier with power source for pre-amplifier (Oct. 1974)

1. R4 sets gain (with preamp) to $A = \frac{R4\ (ohms)}{200}$.
2. All resistors marked * are ± 1%, otherwise ± 5%.
3. R1 & R2 are determined by cable lengths.
4. Capacitor C_3 was added to reduce level of 20K Hz converter noise. It was not present in the Orlando calibration unit. It reduces the sensitivity at 300 Hz by about 0.1 dB. Corner frequency (−3dB Point) is at 1.7 K Hz so calculated drop at 600 Hz is 0.5 dB and at 300 Hz is 0.2 dB. Use calibration runs of Jones & Petronio to get exact value. (Measured values in May 1973 − 1.2 dB at 1 K Hz and 0.1 dB at 300 Hz).
5. D1 & D2 are W diodes (HCSD), Dwg. #743H028, Type D4.

Fig. 16 - Termination Amplifier

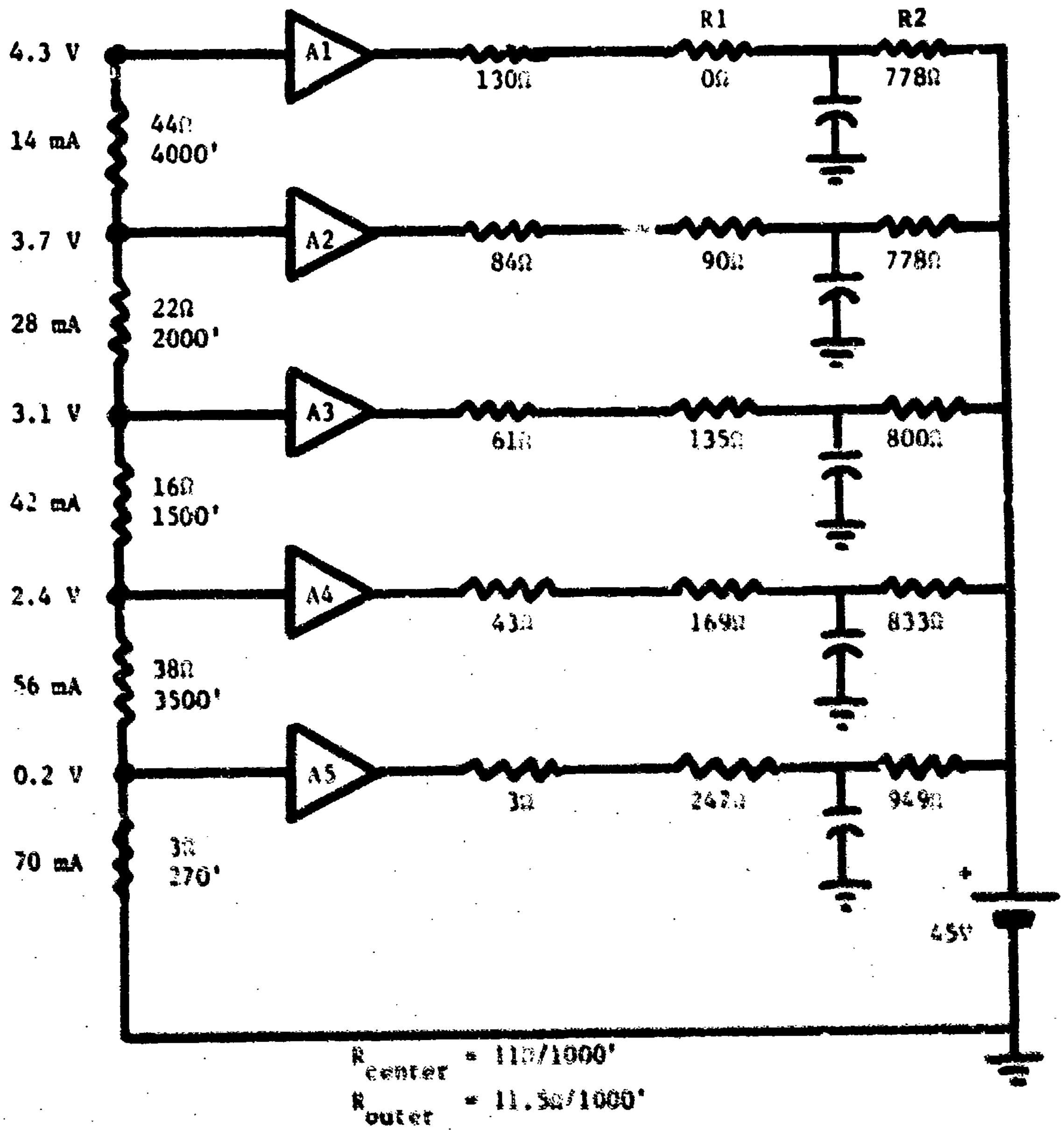


Fig. 17 - Resistance Values of Cables and of Resistances R1 and R2 in Termination Amplifiers

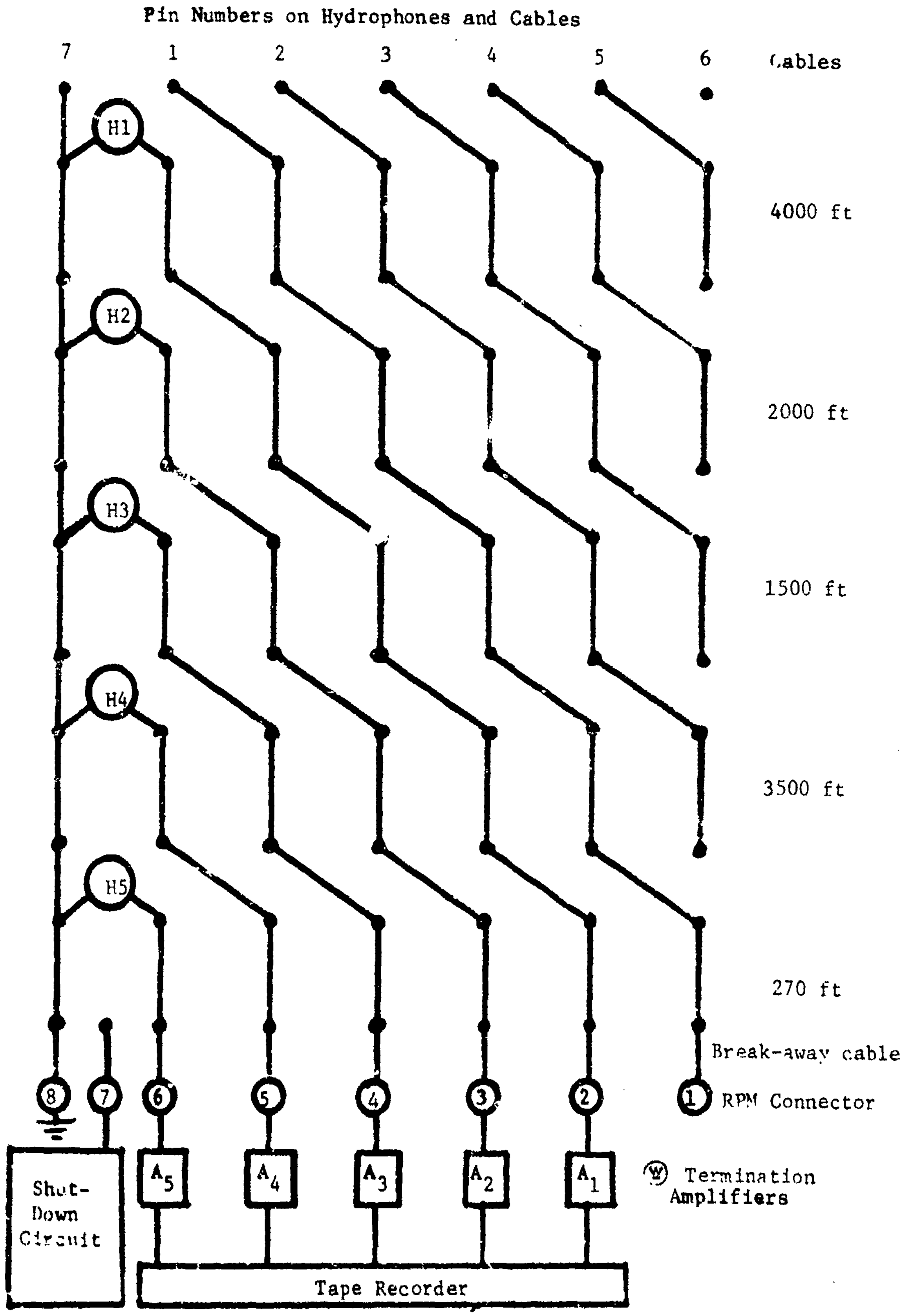


Fig. 18 - Array Wiring Diagram

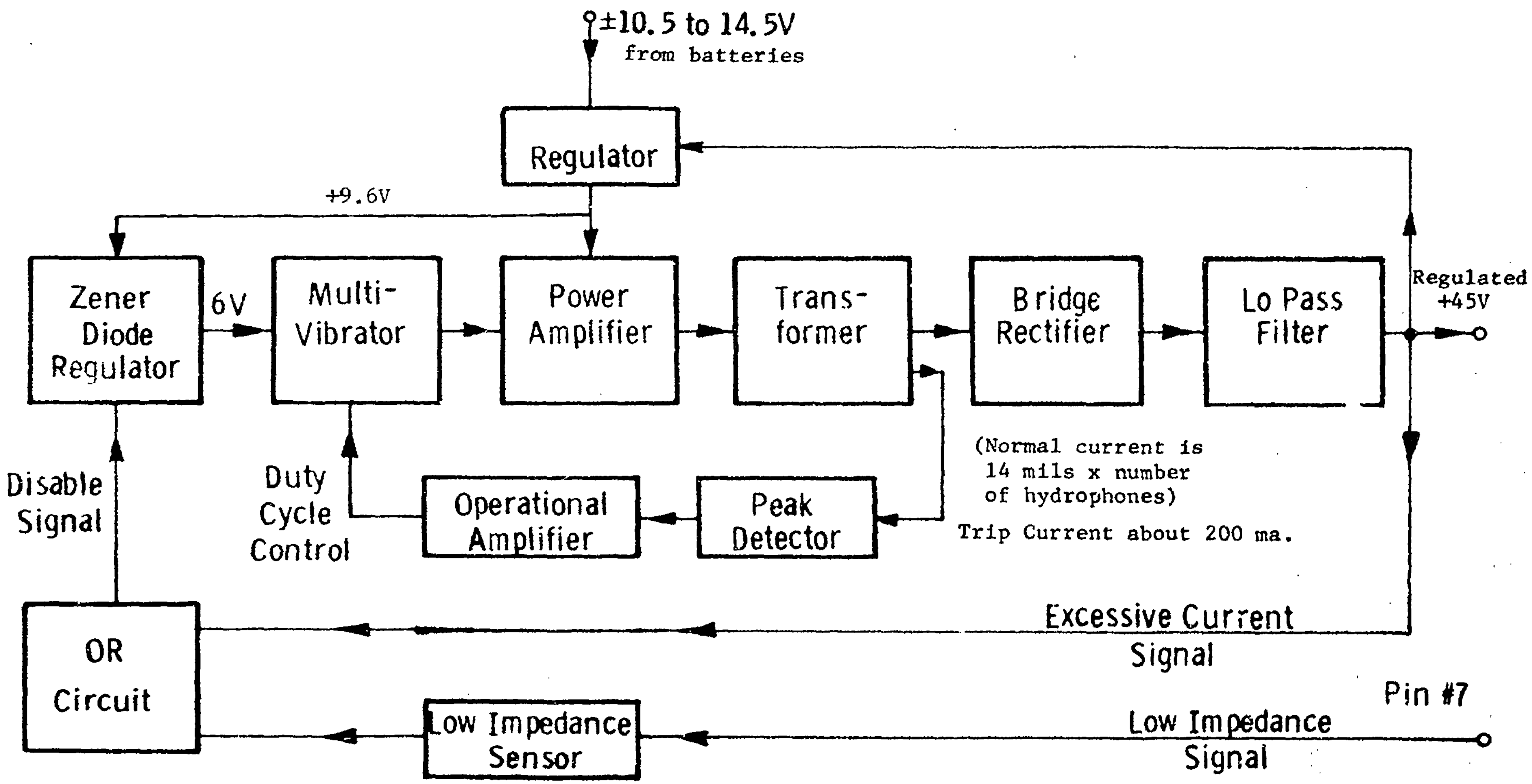
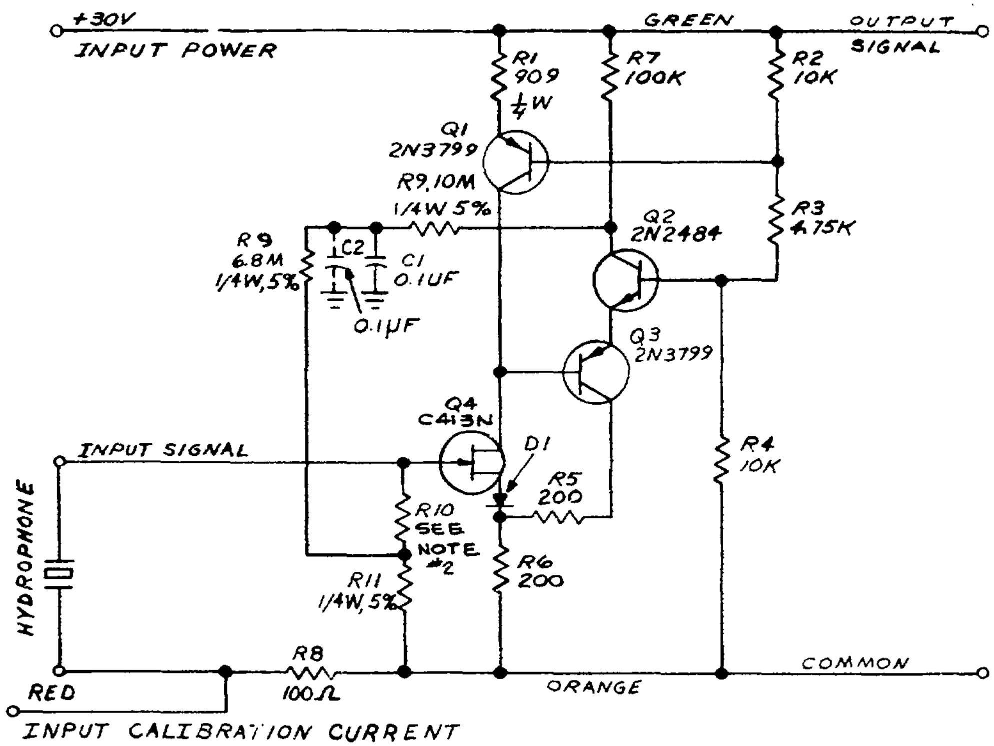


Fig. 19 - Power Converter Block Diagram



NOTES:

1. TEMPORARILY SET R11 = 2.2 MΩ AND SELECT R12 TO OBTAIN 8VDC ACROSS R7 WITH A 1 μF CAPACITOR ACROSS THE INPUT
2. INSERT A 5 MΩ POT FOR R11 AND APPLY. AN INPUT SIGNAL THROUGH A 1 KΩ RESISTOR IN SERIES WITH A 0.0056 μF CAPACITOR OBSERVE THE VOLTAGE ACROSS R7 WITH AN OSCILLOSCOPE AND SWEEP THE INPUT SIGNAL FREQUENCY FROM 100 HZ TO 1 HZ. ADJUST THE POT TO OBTAIN A FLAT (NON PEAKED) RESPONSE WHICH IS DOWN @ 10HZ BY NO MORE THAN 1 DB. IN SOME AMPLIFIERS, C2 MUST BE ADDED TO OBTAIN THIS RESPONSE. MEASURE THE POT RESISTANCE AND MAKE R11 THIS VALUE USING TWO 1/4 W 5% CARBON RESISTORS.
3. C1, C2 ARE MONOLITHIC CERAMIC CAPACITORS.
4. R1-R8 ARE 1% METAL FILM ON DIELECTRIC ROD 1/8 W RESISTORS UNLESS OTHERWISE NOTED.
5. R9-R12 ARE 1/4 W, 5% CARBON RESISTORS.
6. D1 IS A UNITRODE U111A DIODE.
7. TRANSISTORS AND FET'S ARE HOUSED IN ALUMINUM CASES.
8. AN AC VOLTAGE ACROSS R8 WILL BE AMPLIFIED BY 100 BY THE COMBINED PRE-AMP AND TERMINATION AMPLIFIERS.

Fig. 20 - Regulator for Power Converter

NOTES:

1. ALL RESISTORS ARE $\frac{1}{4}$ W, ± 5% UNLESS OTHERWISE NOTED.
2. ALL POLARIZED CAPACITORS ARE 35V TANTALUM UNLESS OTHERWISE NOTED.
3. IN TEST, APPLY POWER TO POWER SUPPLY UNIT BEFORE CONNECTING TEST FIXTURE
4. WITH NO CABLE CONNECTED, CONNECT A 600Ω 4WATT RESISTOR AT A6 TO SIMULATE HYDROPHONE LOAD. VOLTAGE SHOULD BE 45 VOLTS. TO SIMULATE AN OVERCURRENT SHUNT WITH A 200Ω RESISTOR AND UNIT SHOULD SHUT DOWN.
5. TO SIMULATE A BREAK AWAY CONDITION ATTACH A 20KΩ RESISTOR BETWEEN GROUND AND PIN #7 OF THE BREAK AWAY CABLE.

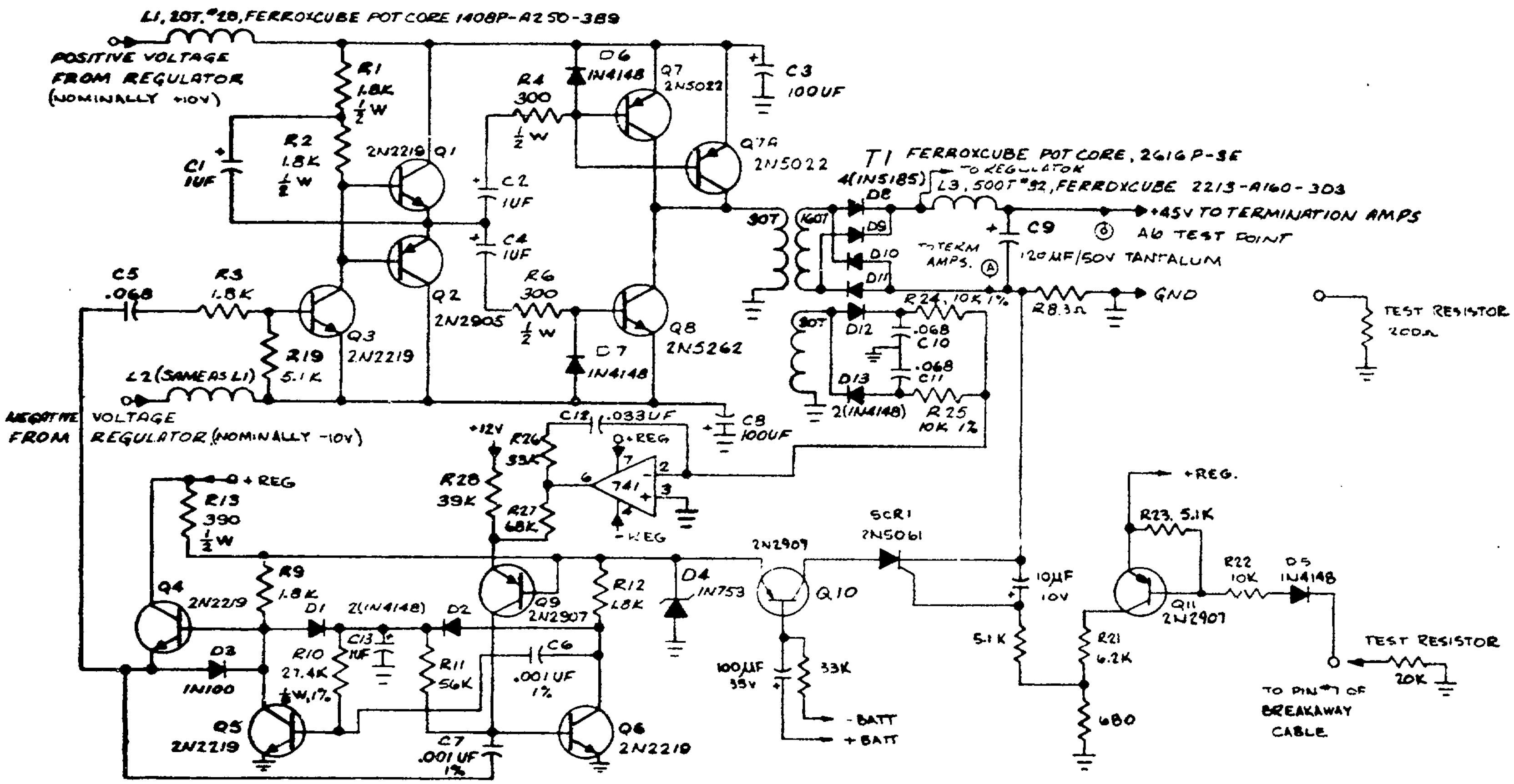


Fig. 21 - Power Supply Unit for ACODAC

4. CABLES AND CONNECTORS

The cables prepared for this deployment are shown in Fig. 1. Cable sections K and I were connected together with a coupler unit to obtain a 1500 ft distance between hydrophones #3 and #4. Cable sections E and L were coupled to provide 3500 ft separation between hydrophones #4 and #5. The cable wiring diagram is given in Fig. 18. In spite of extensive tests of connectors prior to deployment there was evidence that three of the twelve connectors leaked during deployment. These had a blue-green deposit on the pins which had a positive d.c. potential of 38 V during operation. These were the male connectors that were molded onto the lower ends of hydrophones #2, #3, and #4, as shown in Fig. 22. There was no damage to the polyurethane or to the pins.

The connector geometry is shown in Fig. 23. The first connectors made by Ex-Con for had a space "S" behind the connector to be free flooded with water. On the first deployment some of these spaces failed to fill with water and the connector was badly deformed. This problem was corrected by drilling two holes "H" into this volume so water could easily fill the space and provide an axial force on the connector when it was deployed in the ocean. The Ex-Con Corporation,who molded these connectors, felt there was less danger of water leaking into the back of the connector if the space "S" was completely filled with polyurethane during connector potting, so this was done. This gives a much longer bonding length for the seven wires but it does not give the connector much freedom to move axially once the metal split coupler is in place. In the hydrophone pressure tests at Pittsburgh and at Orlando, no leakage occurred but no split couplers were used. When a split coupler is employed it rigidly positions the metal portion of the hydrophone relative to the metal cable termination. If either the male or female molded polyurethane connectors are not accurately molded, then

Fig. 22 - Ends of Three Electrical Connectors that had a Blue-green Deposit Due to Water Leakage

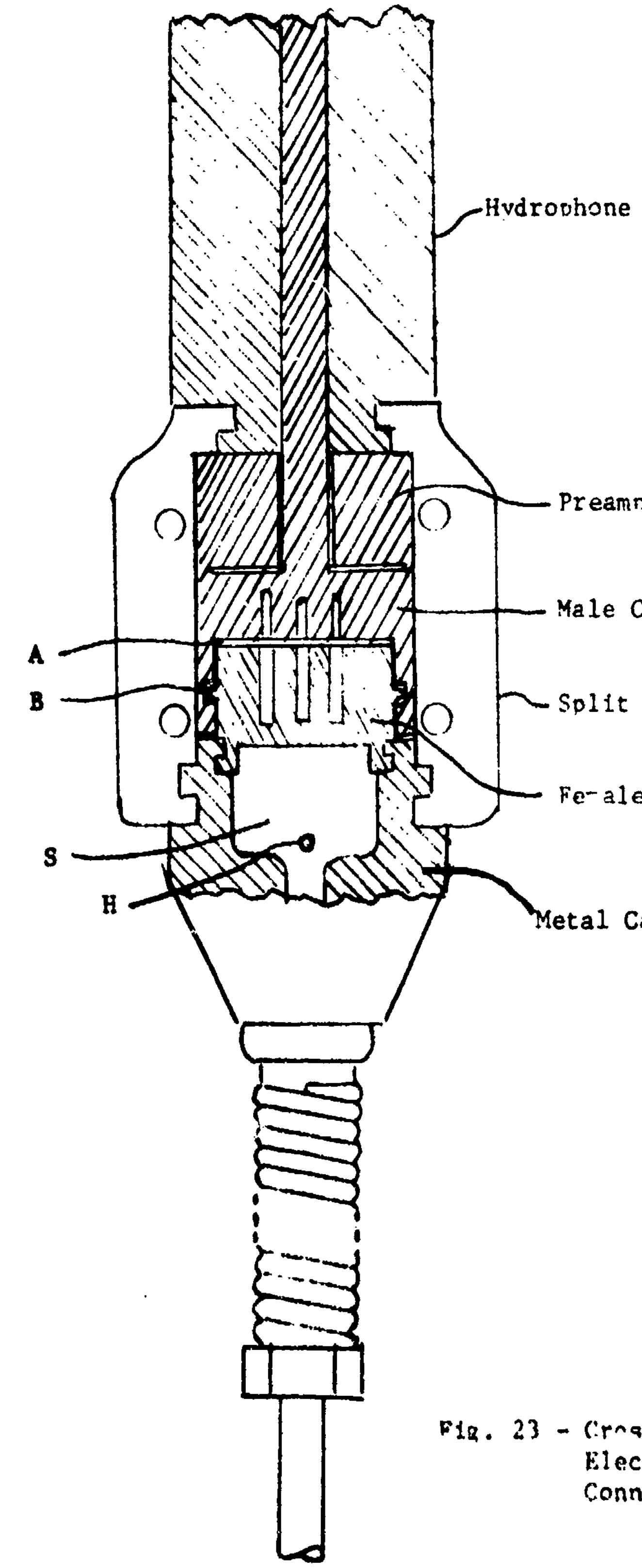


Fig. 23 - Cross-sectional View of Electrical and Mechanical Connector

the two flat surfaces at the face of the connectors may not be parallel or may not be in intimate contact. If the connector is not flexible enough so that the two halves can be pushed together by water pressure, then at great depths a little water may force its way past the "O" ring and into the region "A" of Fig. 23. This small amount of water draws only a small current but the electrolysis of the water generates a fluctuating signal that produces noise at the output of the termination amplifier. Possibly a heavy layer of silicone grease in the "A" region will cure this leakage problem. However, when new connectors are molded they should be made with a region "S" which can readily fill with sea water to exert an axial force on the two halves of the connector.

5. FLOATS

The array was deployed near Bermuda where the bottom depth was 4030 meters. The array was held upright by a large spherical float that was capable of withstanding the 3.7 MPa pressure at a depth of 370 m. This unit has a buoyancy of 1100 lbs. Pairs of 17 inch glass floats were chosen so as to provide a tension that varied from 874 lbs at the bottom of the array to 1100 lbs at the top of the array. See Table 2. The last column of this table gives the tension at each hydrophone after the AMF was released and the top float was on the surface of the ocean. The tension along the array varied from 80 lbs at the bottom to 306 lbs at the top. The float spacings are given in the Appendix.

TABLE 2 - Tension Values

Cable Length ft.		Weight in Water lbs.	Wt. of each Section lbs.	Pairs of 17" Glass Balls	Float Buoyancy lbs.	Net Buoyancy lbs.	Tension Deployed lbs.	Tension After Release
	Top Float				1100		1100	306
500		90						
	Clevis	8	116	1	112	-4		
50		10						
	#1 Hyd.	16					1096	302
4000		800	816	7	784	-32		
	#2 Hyd.	16					1064	270
2000		400	416	4	448	+32		
	#3 Hyd.	16					1096	302
500		100						
	Coupler	8	324	2	224	-100		
1000		200						
	#4 Hyd.	16					996	202
1000		200						
	Coupler	8	724	6	672	-52		
2500		500						
	#5 Hyd.	16					944	150
270		54	70	0	0	-70		
	AMF & Clevis	8					874	80
		80	80			-80		
11820	TOTALS	2546	2546		2240	-306		

6. TESTS

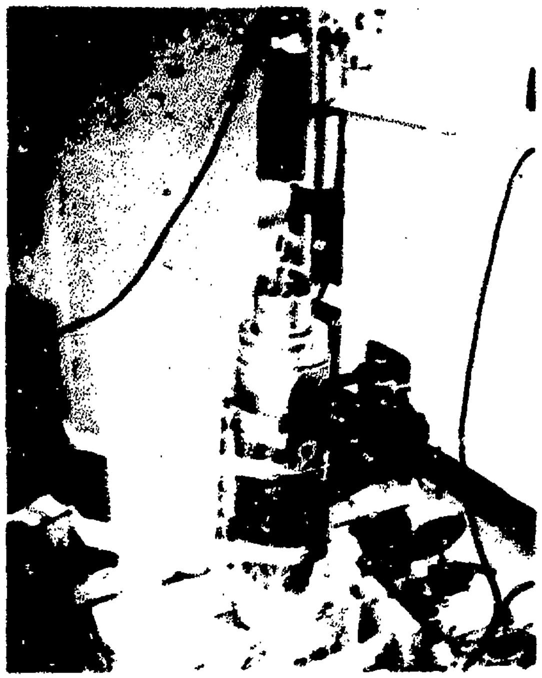
Tests were performed at eight locations in preparation for this deployment.

6.1 Pittsburgh Tests

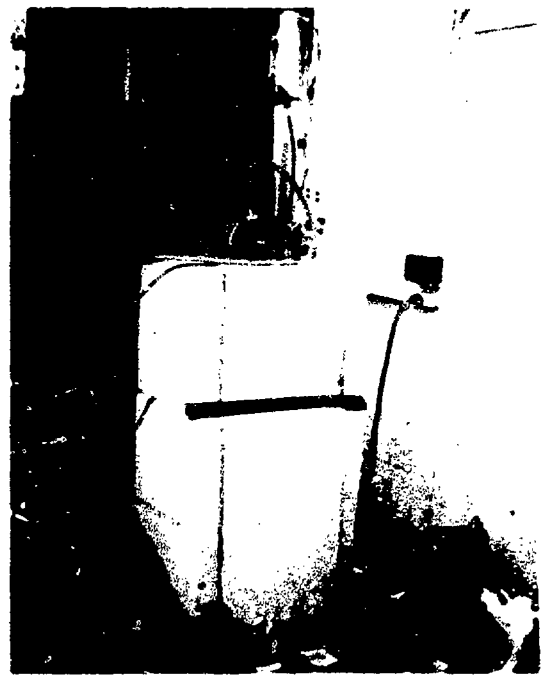
All hydrophone units were pressure cycled in oil in the equipment shown in Figs. 24 and 25 at the Westinghouse Research Laboratories in Pittsburgh, Pa. The pressure was increased linearly over a 15 minute period up to 65 MPa (10,000 psi) and then decreased linearly at the same rate back to 0.65 MPa pressure. The pressure cylinder was encased in styrofoam and cooled to 4°C with liquid nitrogen. The units were cycled ten times before being sent to NRL for calibration.

After modification of the power converter unit was completed, the unit was tested with a load resistor of 600 ohms. The battery voltage was varied from 10.5 to 14.5 volts and the +45 volts remained unchanged. To simulate overload conditions a 200 ohm resistor was placed across the 600 ohm resistor. This caused the unit to shut down. To simulate opening of the break away cable during retrieval of the array, a 20 kΩ resistor was placed between ground and pin 7. This caused the unit to shut off, so the voltage on the cables terminals would be reduced to zero. The spare unit was then modified and tested in a similar manner.

After resistors R1 and R2 in the five termination amplifiers were changed to the values appropriate for the Bermuda array cable lengths, the units were each tested to be certain the overall gain was 40.0 dB. The spare unit was also modified and tested in the same way.

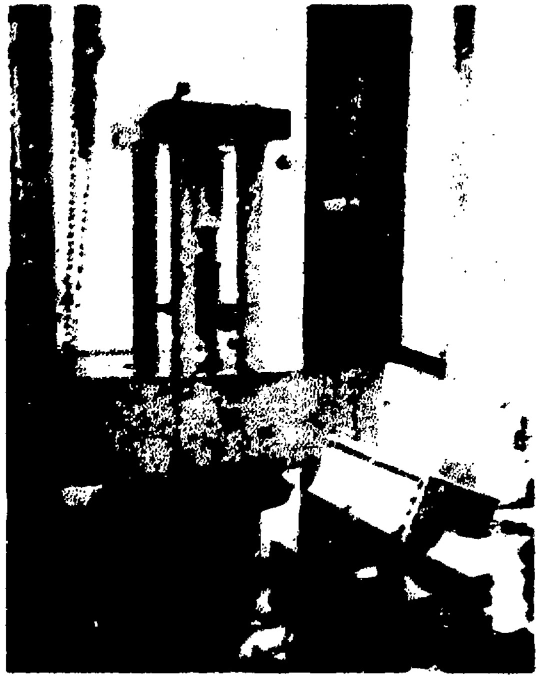


(a) Pressure Container for Hydrophone

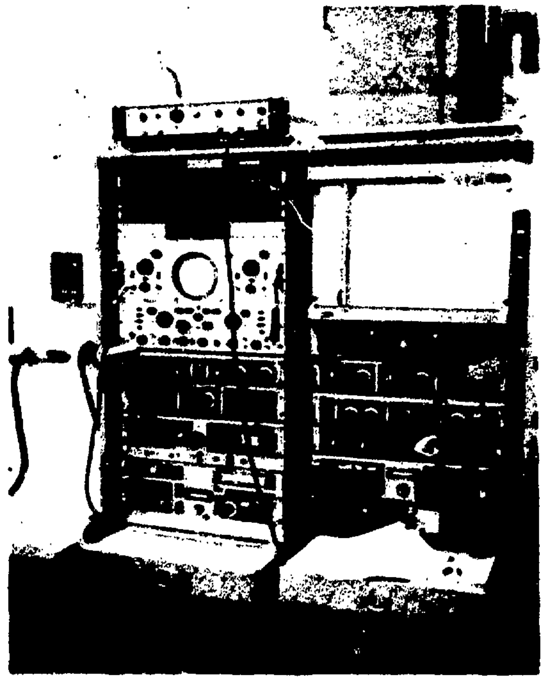


(b) Styrofoam Enclosure for Cooling of Pressure Container

Fig. 24 - Equipment at R&D Laboratory for Pressure Cycling Hydrophones at 4°C



(a) Hydraulic Press for Generating Pressure in Test Chamber



(b) Control Circuits

Fig. 25 - Equipment at R&D Laboratory for Pressure Cycling Hydrophones at 4°C

6.2 Annapolis Tests

In order to check out the connector modifications that were made by Ex-Con Corp., a sample connector with a new split coupler diameter was sent to the Westinghouse Ordnance Division at Annapolis, Md. where pressure tests were made. This connector is illustrated in Fig. 26. The pressure was cycled to 55 MPa at 22°C and the resistance between terminals was measured. There was no evidence of water leakage. The constraint of a split coupler was simulated by a pair of aluminum blocks which bolt together and clamp the male and female ends of the connector.

6.3 Orlando Tests

Fifteen transducer assemblies were sent to the Naval Research Laboratory at Orlando, Florida for calibration. Sensitivity measurements were made at static pressures from 0.7 to 55.1 MPa over a frequency range from 2 Hz to 1000 Hz. Tests were conducted at 2°C and 22°C. The results are tabulated in reference 5. Data for the five transducers used in this deployment has been graphed in Figs. 4 through 13. These units each exhibit a linear variation in sensitivity with pressure so that a precise value of sensitivity requires a knowledge of the deployment depth of each hydrophone. Table 1 gives the appropriate sensitivities for each of the units at the actual deployment depth. The frequency response on all five units is substantially flat from 10 Hz to 600 Hz. The response at 4.5 Hz is down at least 10 dB from the midrange value so the sensitivity to strumming is much less than that of the original WX-VERAY hydrophones.

6.4 Jupiter Tests

Some tests were carried out at the Ex-Con Corp. facilities in Jupiter, Florida. The cables that had been used on earlier deployments were inspected for cable damage and impedance measurements were made between wires and between each wire and the steel cable strands. After the old cables had been modified by Ex-Con Corp. for the Bermuda deployment, they were again tested for leakage resistance at a d.c.

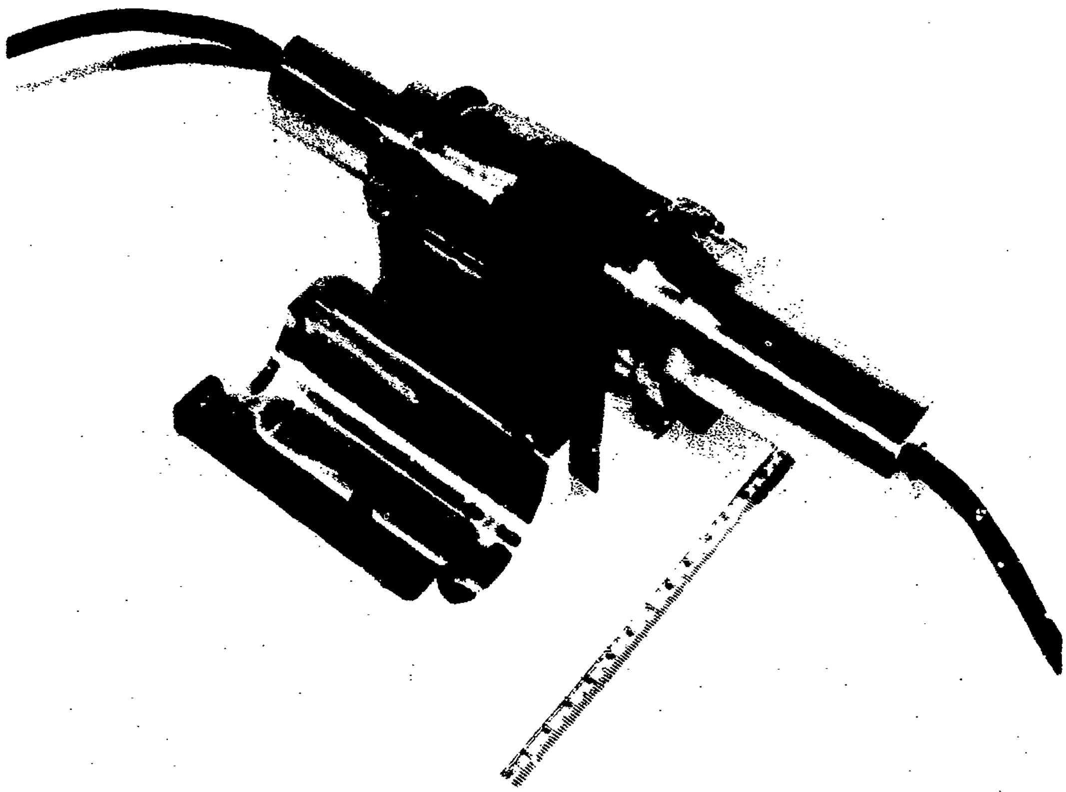


Fig. 26 - Aluminum Fixture Used to Test the Electrical Connector Design

potential of 500 volts. To check out the entire array all of the reels containing cables to be used were placed in a circle, the five hydrophones were attached and all of the split couplers bolted in place. Each of the hydrophones was immersed in a container of water for eight hours and acoustic tests of the entire array were then made using the Ⓦ termination unit which consists of a power converter and five termination amplifiers. An acoustic source at 2360 Hz was used which could be immersed in the water container. A 320 Hz source driving a loudspeaker in air was also used. There was no significant difference in the performance of the units due to the water immersion and no evidence of water was found in the connectors when the hydrophones were removed.

6.5 Hollywood

Since the cables had been stored outdoors in Florida for 18 months following an earlier deployment, it was considered desirable to test all of the cables in water. The six cable reels were taken to a boat elevator in Hollywood where they were immersed overnight in three meters of ocean water with the connectors all supported by ropes out of the water. Then impedance measurements were made between all seven conductors and between the steel strands and each conductor. All resistances measured greater than 1000 megohms. The cable reels were loaded onto a truck and driven to Miami, Florida where they were placed aboard the R/V Chain.

6.6 St. George's Harbor

While the R/V Chain was moored in the harbor at Bermuda, all but one of the six reels of cable were rewound onto wooden reels in such a way that the male or bottom end of each cable was on the outside of the reel and the female or top end of the cable was on the inside of the reel. When the cable sections were later transferred to the trawl winches, the outside end was the upper (female) end of the cable.

The cables were lashed into place around the base of the hydraulic crane located on the #1 deck. The hydrophones were connected between cables and the bottom cable was attached to the Ⓦ termination unit. An acoustic signal from the portable acoustic test unit described in the Phase II report was used to check each of the hydrophones mounted between the cable sections. This unit has a calibrated pickup transducer mounted near the speaker that has a sensitivity of -138 dB re 1 V/μPa. The measured sensitivity in air of the five units was as follows:

Hydrophone Location	Ⓦ Number	Sensitivity in air dB re 1 V/ Pa
#1 top	A17	-148
#2	A19	-158
#3	A5	-148
#4	A21	-145
#5	A23	-148

The lower sensitivity of A19 was attributed to the presence of an air bubble in the oil surrounding the ceramic cylinder. When deployed such a bubble will be desolved in the oil and will not degrade the performance of the hydrophone.

6.7 R/V Chain, Leg 4

After the ship was underway, all hydrophone units were checked electrically by connecting a signal between the shell and the #6 pin. This input signal was coupled to the input stage of the preamplifier through the capacity that exists between the metal hydrophone case and the electrodes of the ceramic cylinder. The output voltage from the termination amplifier was measured. The table below gives the ratio of these two voltages.

Hydrophone Location	Number	$\frac{V_{out}}{V_{in}}$
#1	A17	1.10
#2	A19	1.00
#3	A5	1.05
#4	A21	0.90
#5	A23	0.87

On November 11, the record power module unit (RPM) became available. The termination box was mounted. All five hydrophones were attached between the cables which remained on the wooden reels. A 243 Hz signal from the portable acoustic test unit was used to check each hydrophone. The output signals from each were as follows:

Hydrophone Location	Number	Output Voltage
#1	A17	.364
#2	A19	.546
#3	A5	.558
#4	A21	.447
#5	A23	.558

Next the termination amplifier outputs were connected to the five amplifiers in the RPM unit. With 120 Hz applied to the speaker the voltage at the input to the magnetic head driver amplifier was measured when the speaker was placed in proximity to each hydrophone. The results are given as follows:

Hydrophone Location	Number	Voltage
#1	A17	.300
#2	A19	.490
#3	A5	.500
#4	A21	.463
#5	A23	.500

After the entire array was in the water, but before the RPM unit was put into the water, a last check was made. Strong signals were received from locations 1, 4, and 5, and somewhat weaker signals from locations 2 and 3. The stronger signals near the #1 unit were expected because that unit was near the large top float. Units 4 and 5 were close to the ship and could be expected to pick up ship noise. Both Dave Bitterman and Jess Stanbrough said that these signal levels were what they normally received with that type of array before the anchor was released.

6.8 R/V Chain, Leg 5

After retrieval of the array on November 14, 1974, the five hydrophones were tested in air at 243 Hz using the portable acoustic test unit to check their sensitivities. Next an electrical signal was introduced between the hydrophone shell and the power converter ground point and the output voltage measured. The results of these two tests are given below.

Hydrophone Location	Hydrophone Number	Sensitivity in air dB re 1V/ Pa	$\frac{V_{out}}{V_{in}}$
#1	A17	-147.8	1.15
#2	A19	-145.9	1.04
#3	A5	-145.0	1.08
#4	A21	-146.3	0.88
#5	A23	-145.8	0.88

Note that the measured sensitivity of unit A19 in air is about 12 dB greater than it was before deployment. The assumed air bubble mentioned in Section 6.6 evidently desolved in the oil during deployment as expected. The measured sensitivity of the other four units agreed within 3 dB of their previous values. Ship noise and variations in transducer positions make it difficult to reproduce on deck acoustic sensitivity measurements to an accuracy better than ±3 dB.

7. DEPLOYMENT OF ARRAY

The array was deployed from the R/V Chain near Bermuda November 12, 1974 in 4030 meters of water at 32° 24.86 N, 64° 16.7'W. Deployment required 4 hours 58 minutes, exclusive of time lost due to a winch repair. The array was launched in three sections and so some time was lost in attaching two hydrophones and in winding a 270 ft cable section from a wooden reel onto the trawl winch. The winch was stopped about 90 seconds to attach each of the 20 pairs of floats. A deployment time breakdown follows:

Reeling out 3610 m of cable	122 minutes
Attaching 20 float pairs	30 minutes
Winding 82 m of cable on winch	18 minutes
Attaching two hydrophones	24 minutes
Deploying anchor and RPM	104 minutes
Total	298 minutes

If a winch the size of the one on the North Seal had been available, all of the array could have been placed on the winch and the deployment time would have been reduced by 42 minutes. If the cable was neutrally buoyant so that no floats were required along the length, this would have saved another 30 minutes. The line was reeled out at a rate of approximately 30 meters per minute.

8. RETRIEVAL OF ARRAY

The array was retrieved on November 14, 1974 after being in the ocean 59 hours and 42 minutes. The RPM unit was retrieved first in 2.5 hours. The top float and then the array were retrieved in 3.3 hours for a total retrieval time of 5.7 hours. There was evidence that a small amount of water had leaked into three of the twelve Ex-Con connectors. This problem is discussed in detail in section 4.

9. RECORDED DATA

The magnetic tape obtained on this deployment has not yet been processed. However, the preliminary one-third octave record made at 100 Hz indicates that the leakage into the three connectors generated sufficient noise to mask the signals from the top four hydrophones. The signal from the bottom hydrophone appears to be satisfactory over most of the time that the array was in the ocean. Unfortunately, because of the unavailability of a second array, a comparison of the data from this hydrophone with one under similar sea noise conditions is difficult if not impossible at this time. Had the deployment been in an area where previous measurements had been taken, some sort of comparison could be made. It will be instructive to determine the increase in recorded noise level as the ship approached the array for recovery. This noise should be similar to that achieved on other deployments of the same depth unless the ship noise was reinforced by reflections from a different bottom geometry.

10. CONCLUSIONS

The deployment demonstrated the feasibility of a vertical array using type Vector 738P armored well logging cable containing hydrophones mounted between cable sections. The array was easily deployed from two trawl winches and wound onto these same winches on recovery. Some of the Ex-Con connectors leaked water. This appears to be due to a small air space that exists between the face of the two connectors when they are clamped with a split coupler. A more liberal application of Silicone grease in this region should cure this problem. Before the next deployment of this array, it would be wise to suspend the array in deep water to be certain that the electrical connectors do not leak. The noise data obtained by the bottom hydrophones should be compared with any records that have been made in a similar location and depth. The hydrophones with the new preamplifiers using pressurized encapsulation of the semiconductor components proved to be satisfactory.

11. REFERENCES

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2. C. H. Jones, "LRAPP Vertical Array of Hydrophones, Phase II," Westinghouse Research Report 73-9M7-VERAY-R1, June 1973.

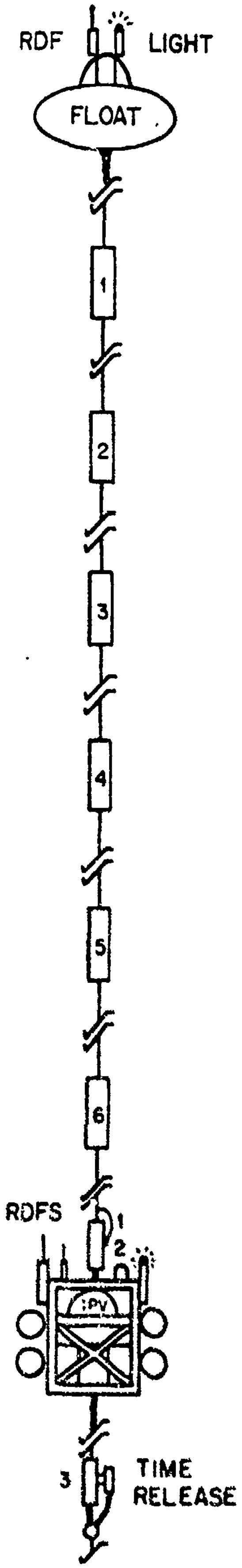
3. C. L. Hikes, "ACODAC Array: Cable, Terminations, and Connectors," Westinghouse Report OER #73-19, July 1973.

4. C. H. Jones, "LRAPP Vertical Array - Phase III," Westinghouse Research Report 73-9M7-VERAY-R2, November 1973.

5. H. J. Hebert, "Calibration of Westinghouse WX-VERAY-3 Hydrophones, Serials A-3, A-5C, A-6C, A-7, A-8, A-9, 11, A-12C, A-14, A-17, A-19, A-20, A-21, A-23, and 92" Naval Research Laboratory.

APPENDIX

DEPLOYMENT RECORD OF THE CHIEF SCIENTIST



ACODAC DEPLOYMENT NO. 33 SHIP R/V CHAIN

SYSTEM 1A2 LENGTH 3635 CRUISE 117

DEPTH (~~XX~~c) 4030 MTRS -- FMS

LOCATION (LAT) 32°24.86N (LONG) 64°16.7W

DATE/TIME DEPLOYED 0923Z 12 Nov. 1974 z

RECOVERED 14 Nov. 74 2105 z
" 32°24.74'N 64°16.81'W

1. RECORDING

TIME CODE SYNC 0000= 0.027 Z DATE 12 Nov. 1974

TAPE START 12 Nov. 1200 Z DUTY CYCLE 100
Day 316

2. HYDROPHONES WESTINGHOUSE
WX - VERAY-1

Station No.	Ser.	Mtrs. Abv. Bottom	Depth (Corr)	T°C
1	A17	3490	540	16
2	A19	2270	1760	4.2
3	A5	1660	2370	3.5
4	A21	1207	2823	3.1
5	A23	140	3890	2.3
6				

3. RELEASES/TRANSPONDERS

AMF

	CH. NO.	FREQ KHz
1 Top	9	10
2 IPV	6	10
3 Btm	7	11
4 Btm	8	10

GEODYNE

SER. NO. ______

NO. IN COUNTER ______

DATE/TIME, START ______

DATE/TIME, STOP ______

4. LOCATION AIDS

	OAR RDF				OAR FLASH	
	CH. NO.	FREQ MHz	S/N	HRS	S/N	HRS.
Float	C	27.095	921	100	-	100
IPV	A	26.995	480	~~100~~	288	100
IPV	D	27.145	534	100		

WHOI - 1972
DWG - ES

- A1 -

J. Ettenbaugh

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ITEM #	DESCRIPTION 12 NOV 1970	TIME OVER-BOARD Z	DEPLOYMENT REMARKS	TIME ON-BOARD	ON SITE 1515Z RETRIEVAL REMARKS
1	OCT FLOAT	0310Z	ON SITE 0300Z POLYFORM ON MAST	1745Z	RADIO ANT BROKEN — 1521Z FIX
2	RDF	"	TOOK A BANGING ON LAUNCH CH C 100 HR	"	NO SIGNAL
3	FLASH	"	OK 100 HR	"	OK
4	DEPTH GAUGE	"	BENTHOS #1078	"	
5	SWIVEL/CHAIN ASSEMBLY	"	(FLOAT NOT STRAIGHT UP)	"	
6	500 FT WIRE	0310Z		1800Z	
7	2 17"Ø GB @ 250	0311		1803Z	
8	HYDROPHONE 1	0316	W SER A17	1809Z	
9	ARRAY TO 2/m CABLE	0317	GB 17"Ø at 500FT. TADIC	-	
10	2.17"Ø BENTHOS ①	0321	FROM ITEM 8 500FT	1819	
11	2.17"Ø GB BENTHOS ②	0326	500FT. FROM ITEM 10	1827	
12	2.17"Ø GB BENTHOS ③	0333	500FT FROM ITEM 11	1833	
13	" " ④	0340	" " ITEM 12	1840	
14	" " ⑤	0346	" " ITEM 13	1845	
15	" " ⑥	0351	" " ITEM 14	1853	
16	" " ⑦	0357	" " ITEM 15	1905	
17	HYDROPHONE #2	0403	W SER. A19 500FT FROM ITEM 16	1913	
18	2000 FT E/M CABLE	0403	4 PC 17"BGB @ 500FT INTERVALS	1913	

Notes by J. Hettenbaugh
WHOI

ITEM #	DESCRIPTION	TIME OVER-BOARD	DEPLOYMENT REMARKS	TIME ON-BOARD	RETRIEVAL REMARKS
[illegible]	[illegible] (1)	0409	500 FT FROM ITEM 17	1930Z	
[illegible]	" (2)	0414	" " 19	1936Z	
21	" (3)	0418	" " 20	1944Z	
22	" (4)	0422	" " 21	1952Z	
24	HYDROPHONE #3 [illegible]	0438	SEE AS " " 22	2000	LEAKED - 3 PINS GREEN
24	2-17" [illegible]				
[illegible]	[illegible] C/B CABLE	0439	3 PR 17' GA AT 500 FT INTERVALS	2010	
25	2-17" [illegible] (1)	0445	500 FT FROM ITEM 23	2017	
26	" " (2)	0613	[illegible] BROKE DOWN " 25	2023	
27	HYDROPHONE #4	0619	W A21 500 FT FROM ITEM 26	2029	
28	[illegible] 3/4" C/B CABLE	0649	6 PAIR 17' GA 500 FT APART	2030	
29	2-17" [illegible] (1)	0624	500 FT FROM ITEM 27	2034	
30	" (2)	0630	PLUS CABLE [illegible] " 29	2038	
31	" (3)	0636	" " 30	2043	
32	" (4)	0642	" " 31	2048	
33	" (5)	0647	" " 32	2051	
34	" (6)	0654	" " 33	2054	
35	HYDROPHONE #5 [illegible]	0730	" " 34	2100Z	

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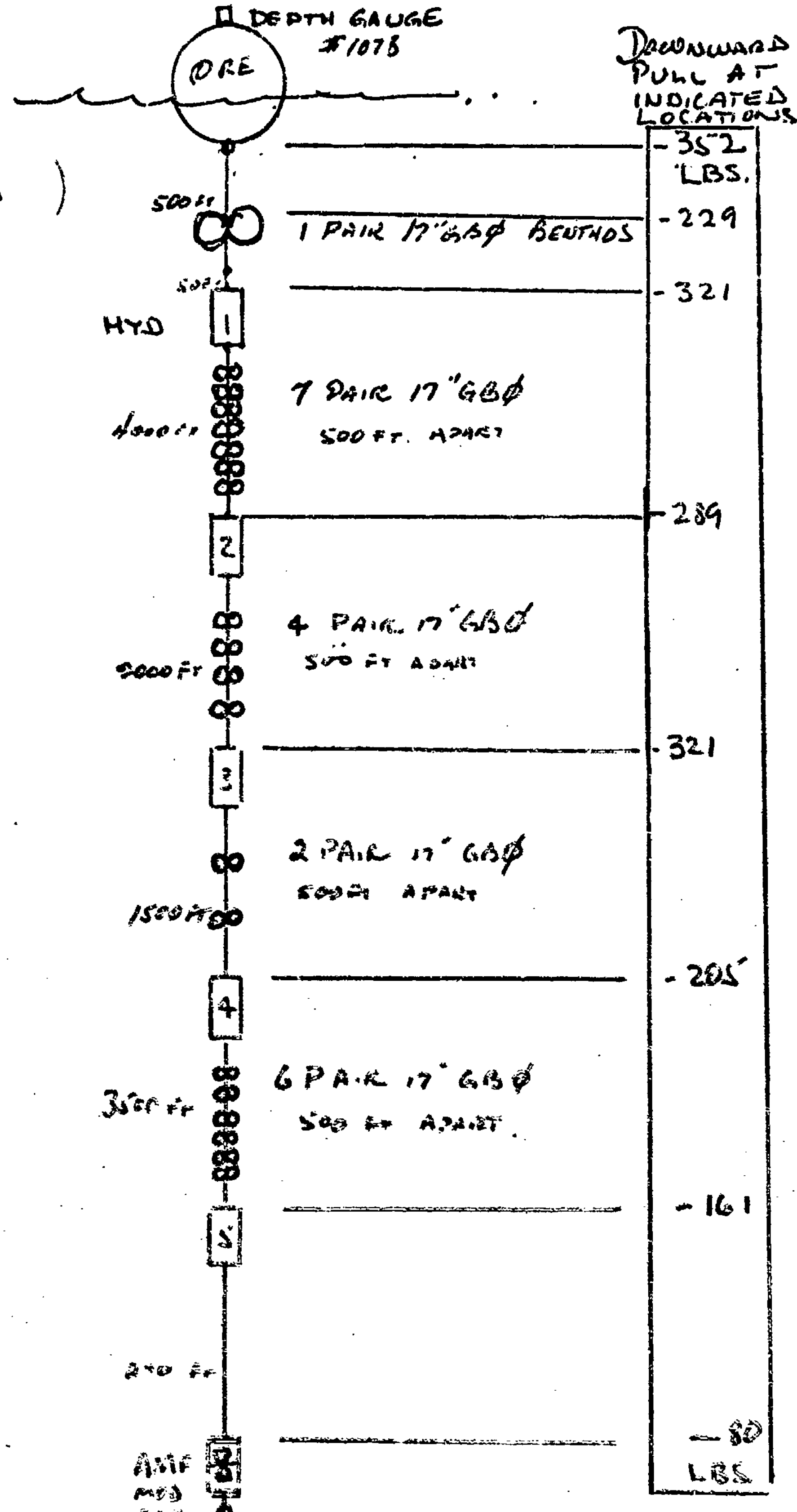
ITEM #	DESCRIPTION	TIME OVER-BOARD	DEPLOYMENT REMARKS	TIME ON-BOARD	Started on site 1515 RETRIEVAL REMARKS
[illegible]	[illegible] CABLE	0730	LAST SECTION TO ARRAY	2104	
37	[illegible] TERMINAL [illegible]	—	2 [illegible] 0.5 MI. GAS [illegible]	2 —	
[illegible]	[illegible]	0923	MODEL 262	2104 ~~[illegible]~~	3 hrs 19 minutes
[illegible]	IPV - [illegible]	0923	SYSTEM [illegible]	1705 Z	GB took some hard bumps
[illegible]	[illegible], CAT [illegible]	"	[illegible]	"	- swells
[illegible]	CHAIN			"	1711Z IPV & ASSEMBLY
[illegible]	[illegible] AME [illegible]		[illegible]	"	ON BOARD (6 MIN.)
[illegible]	[illegible]			N/A	
[illegible]	2500 LB ANCHOR / [illegible]	0923	RAILROAD WHEELS	N/A	
	SUMMARY TIMES				
	DEPLOYMENT START	0310 Z	RETRIEVAL TIME		
	IPV OVER	0923 Z	ON SITE	1515 Z	
	TOTAL ELAPSED	6:13	FLOAT ONBOARD	1745	
	LESS WINCH REPAIR	1:26	IPV ON BOARD	1705	2½ hrs
		4:48	CABLE/ARRAY IN	2105	3⅓ hrs
					5⅚ HRS = 5 HRS 50 MIN
	NET DEPLOYMENT TIME	4 HRS	48 MINUTES		TOTAL RETRIEVAL
					TIME

[illegible signature]



TACODAC
1138 LBS

R.V. CHAIN
11 Nov. 1974

DEPLOYMENT No. 33
12 Nov. 1974
R.V. CHAIN
CRUISE 117

HYDROPHONES
(W) WX-VERAY-1

- AS - 20 PAIR 17" GBØ

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
875 NORTH RANDOLPH STREET
SUITE 1425
ARLINGTON VA 22203-1995

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Report Number	Personal Author	Title	Publication Source (Originator)	Pub. Date	Current Availability	Class.
Unavailable	Beam, J. P., et al.	LONG-RANGE ACOUSTIC PROPAGATION LOSS MEASUREMENTS OF PROJECT TRANSLANT I IN THE ATLANTIC OCEAN EAST OF BERMUDA	Naval Underwater Systems Center	740612	ADC001521	U
Unavailable	Cornyn, J. J., et al.	AMBIENT-NOISE PREDICTION. VOLUME 2. MODEL EVALUATION WITH IOMEDEX DATA	Naval Research Laboratory	740701	AD0530983	U
Unavailable	Unavailable	COHERENCE OF HARMONICALLY RELATED CW SIGNALS	Naval Underwater Systems Center	740722	ADB181912	U
Unavailable	Banchero, L. A., et al.	IOMEDEX SOUND VELOCITY ANALYSIS AND ENVIRONMENTAL DATA SUMMARY	Naval Oceanographic Office	740801	ADC000419	U
3810	Unavailable	CONSTRUCTION AND CALIBRATION OF USRD TYPE F58 VIBROSEIS MONITORING HYDROPHONES SERIALS 1 THROUGH 7	Naval Research Laboratory	741002	ND	U
ARL-TM-73-11; ARL-TM-73-12	Ellis, G. E., et al.	ARL PRELIMINARY DATA ANALYSIS FROM ACODAC SYSTEM; ANALYSIS OF THE BLAKE TEST ACODAC DATA	University of Texas, Applied Research Laboratories	741015	ADA001738; ND	U
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Unavailable	Unavailable	MEDEX PROCESSING SYSTEM. VOLUME II. SOFTWARE	Bunker-Ramo Corp. Electronic Systems Division	741021	ADB000363	U
Unavailable	Spofford, C. W.	FACT MODEL. VOLUME I	Maury Center for Ocean Science	741101	ADA078581	U
Unavailable	Bucca, P. J., et al.	SOUND VELOCITY STRUCTURE OF THE LABRADOR SEA, IRMINGER SEA, AND BAFFIN BAY DURING THE NORLANT-72 EXERCISE	Naval Oceanographic Office	741101	ADC000461	U
Unavailable	Anderson, V. C.	VERTICAL DIRECTIONALITY OF NOISE AND SIGNAL TRANSMISSIONS DURING OPERATION CHURCH ANCHOR	Scripps Institution of Oceanography Marine Physical Laboratory	741115	ADA011110	U
Unavailable	Baker, C. L., et al.	FACT MODEL. VOLUME II	Office of Naval Research	741201	ADA078539	U
ARL-TR-74-53	Anderson, A. L.	CHURCH ANCHOR EXPLOSIVE SOURCE (SUS) PROPAGATION MEASUREMENTS (U)	University of Texas, Applied Research Laboratories	741201	ADC002497; ND	U
MCR106	Cherkis, N. Z., et al.	THE NEAT 2 EXPERIMENT VOL 1 (U)	Maury Center for Ocean Science	741201	NS; ND	U
MCR107	Cherkis, N. Z., et al.	THE NEAT 2 EXPERIMENT VOL 2 - APPENDICES (U)	Maury Center for Ocean Science	741201	NS; ND	U
Unavailable	Mahler, J., et al.	INTERIM SHIPPING DISTRIBUTION	Tetra, Tech, BB&N, & PSI	741217	ND	U
75-9M7-VERAY-R1	Jones, C. H.	LRAPP VERTICAL ARRAY- PHASE IV	Westinghouse Electric Corp.	750113	ADA008427; ND	U
AESD-TN-75-01	Spofford, C. W.	ACOUSTIC AREA ASSESSMENT	Office of Naval Research	750201	ADA090109; ND	U